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THE DETECTION AND MEASUREMENT OF CONDUCTIVE DEAFNESS

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WITH the expanding scope of modern aural surgery in the treatment of conductive deafness, the otologist must logically attach great importance to the detection and measurement of this defect, either with his own tests or those made by the audiologist associated with him.

The purpose of this paper is to present some data on the validity,* reliability† and sensitivity‡ of tuning fork tests used in the diagnosis of conductive deafness. As a basis for discussion, we have embodied our findings in a more general consideration of this problem, expressing views that are based upon our experience in this field.

A convenient classification of the tests that we propose to discuss is shown in Table I. Since we have had little experience with the so-called objective tests, these will be omitted.

Rinne Test

In conformity with general practice and the recommendation of the Committee of the Section of Otology of the Royal Society of Medicine (Report of the Committee for the Consideration of Hearing Tests, 1933), we compared an individual's sound perception when the tips of the tuning

* i.e. how well does the test measure what it sets out to measure? (In this case, the presence or absence of conductive deafness.)

† i.e. how self-consistent is the test, or, in other words, to what extent are test results repeatable?

‡ i.e. what minimal degrees of, in this case, conductive deafness will the test detect? This is in contrast to the use of the term to denote the ability of a test to discriminate between two or more groups.

fork's prongs were held close to the meatus with that when the footpiece was applied to the mastoid process. In each case, we tried to arrange for the acoustic axis of the fork and the auditory axis of the ear to coincide. This involved the prongs of the fork and the external auditory meatus being in the same plane. It should be remembered that when Rinne originally described his test in 1855, he compared airborne sound perception with structure-borne sound conduction by placing the tuning fork against the upper incisors.

TABLE I.

TESTS FOR THE DETECTION AND MEASUREMENT OF CONDUCTIVE DEAFNESS

I. SUBJECTIVE

A. QUALITATIVE

(*a*) Tuning Fork
1. Rinne (1855).
2. Weber (1834).
3. Bing (1891) = Occlusion Test.

(*b*) Audiometric
1. Occlusion Test (Reger, 1940)
2. Audiometric Weber (Bunch, 1943)

B. QUANTITATIVE

Combined air and bone conduction audiometry.

II. OBJECTIVE

A. QUALITATIVE

Measurement of acoustic impedance (Metz, 1946).

B. QUANTITATIVE

Combined air and bone conduction audiometry using electro-dermal response.

Validity

Using a 512 c/s Gardiner Brown tuning fork, we performed the Rinne test and otoscopically examined a random sample of a rural population. For ears that were found to be Rinne negative, the probability of the occurrence of changes that could interfere with the sound conducting mechanism was nearly 0·9. For ears that gave a Rinne positive response, the probability of the occurrence of these changes was less than 0·1. The abnormalities that were considered to be potentially productive of a conductive hearing loss of some degree or another were: impacted wax plugs (attempts were made to syringe all ears that showed evidence of wax obscuring a view of the tympanic membrane), scarred or perforated tympanic membranes, congenital abnormalities of the middle ear, serous effusions into the middle ear, or radical, or modified radical, mastoid cavities. The correlation between a negative Rinne result and the presence of conductive deafness is even greater than this analysis indicates. There are two reasons for this. First, this particular analysis did not take into account whether the negative Rinne result was a true negative or a false one. In cases where there is unilateral perceptive deafness, a Rinne negative result may be recorded on that particular ear. The severity

of the unilateral perceptive deafness required to produce a false negative Rinne will depend upon the characteristic* for the particular tuning fork and upon the sensori-neural hearing level of the contralateral ear. It may therefore occur with hearing losses at the frequency in question in excess of about 25 db. only. Our data indicates that, for a rural population, the probability that the Rinne negative result is false is about 0·05. Secondly, a true Rinne negative result (i.e. a negative response not abolished by masking the other ear) associated with normal otoscopic appearances would constitute a clinical diagnosis of otosclerosis. Such a presumptive diagnosis has not been questioned in the innumerable examinations of the middle ear during surgical procedures aimed at improving the hearing loss (Cawthorne, 1960). Thus an ear with a true negative Rinne response will show clinical otoscopic and/or aural microscopic evidence (after reflection of the tympanic membrane) of lesions impairing the functional integrity of the conducting mechanism.

A clinico-histopathological correlation by Polvogt and Bordley (1936) showed that a negative Rinne response was correlated with one or more lesions involving the ossicular chain in every ear in a group with impaired hearing.

Bunch (1941) compared the difference between the air and bone conduction threshold at 512 c/s with the Rinne response for a 512 c/s tuning fork. The air-bone gap was taken as a measure of conductive deafness. The differences between the two thresholds showed two distinct distributions depending upon whether the Rinne response was positive or negative. The two distribution curves intersected at a point equivalent to about 20 db. conductive deafness, but there was little overlap. The results therefore indicated that a Rinne negative response was a correlate of conductive deafnesses with an "air-bone gap" of 20 db. or more.

Reliability

The Rinne test was administered to the 75 individuals (= 150 ears) in our random sample of a rural population. It was repeated about a month later. The first test gave a negative Rinne result on 12 ears. On the second test, one of these negative Rinne responses became positive and another showed sound perception by air conduction equivalent to sound perception by bone conduction. All the ears (144) that gave a positive Rinne response on the first test also gave a positive response on the second test. Both of the ears whose Rinne negative response changed on the second test had conductive hearing losses at 500 c/s of about 20 db. or a little less. This is the level of conductive loss where the Rinne response is changing from

* The characteristic of a tuning fork is defined as the number of units (i.e. seconds heard in air, divided by half-intensity period) that the fork can be heard in air after its sound conducted through bone has ceased. It is therefore an expression of the sound intensity of the tone generated by the fork immediately after the tone has ceased to be heard by bone conduction.

positive to negative (*v.* infra). Moreover, since there was a time interval of about a month between the two tests, it is possible that there had been a slight decrease in the impairment of sound conduction which would influence the Rinne response at this critical level. An accidental catarrhal condition could conceivably account for it. We can therefore conclude that the Rinne is a highly reliable test.

Sensitivity

We have endeavoured to determine the sensitivity of the Rinne test in our survey work by comparing the distribution of thresholds of hearing at 500 c/s for two groups of ears and determining where they intersect. Both groups were taken from a random sample of a rural population examined by one audiologist. One group comprised all ears with a scarred or perforated tympanic membrane and showing a positive Rinne response. The second group comprised all those ears with a true negative Rinne response, except for those ears with a hearing loss of 60 db. or more. The exclusion of the more severely deafened ears was based on the contention that, above this level, the deafness could not be a pure conductive one (Reger, 1944). Each hearing threshold was subject to a correcting factor for the ageing process. We subtracted 1 db. at age 30 years, 2 db. at 40 years, 4 db. at 50 years, 7 db. at 60 years and 10 db. at 70 years. For each of the two sets of data, a normal distribution curve was fitted, using the probit transformation and obtaining the curve of best fit by the method of least squares. The two distribution curves are shown in Fig. 1. The Rinne positive group show an almost perfect fit to a normal distribution. It is also to be noted that the mean hearing loss for the Rinne positive group of scarred and perforated tympanic membranes is greater than 5 db. (calculated mean = 5·5 db.). This is a significant departure from the normal (i.e. zero hearing loss).

The general assumption underlying this method of analysis was that the two groups would jointly comprise a continuum of conductive deafness ranging from zero loss to maximum hearing loss, and that the intersection of the two separate distribution curves would indicate the point where the Rinne response changed from positive to negative. As the graph shows, this point is at a level of nearly 17 db. In other words, when an individual develops a conductive deafness, the Rinne test with a 512 c/s tuning fork will register the deafness when it reaches a level of 17 db at 500 c/s. The area of intersection of the two distribution curves may be attributed to the inter-individual variation of normal thresholds of hearing. Thus, individuals who appear to give a Rinne negative response when the degree of conductive deafness is less than 17 db. are probably those people who originally had more acute normal hearing. Those subjects who appear to give a positive Rinne response with a conductive loss of more than 17 db. are likewise probably people who had less acute hearing originally.

It must be remembered that the data have been presented in terms of the air-conduction hearing loss. Although we have corrected all our thresholds for the ageing process, it may be contended that we have not entirely eliminated a perceptive element in the hearing loss. We believe this is negligible. If there were an appreciable perceptive element contaminating the data it would imply that the Rinne test is even more sensitive than we have concluded it to be.

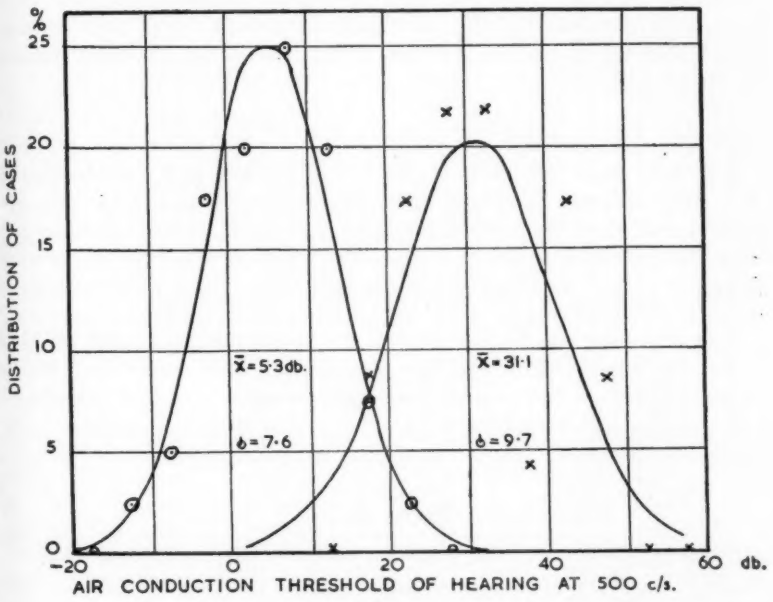

FIG. 1.

Distributions of air-conduction threshold shifts at 500 c/s for (*a*) ears with scarred or perforated tympanic membrane and a Rinne positive response (⊙), and (*b*) ears with a true Rinne negative response (X).

We attempted to calibrate our tuning fork by measuring the decay time in air and then measuring the duration for which the fork could be heard by air conduction after perception of sound with the foot-piece on the mastoid process had ceased. We found that this method gave results having a considerable variation. Although measurement of the decay time of the fork in air is an objective procedure, the duration that the fork is heard by air conduction after it has ceased being heard by bone conduction is a subjective one. Determination of the sensitivity of the Rinne test by calibration of the tuning fork is therefore no more accurate than the

procedure that we have adopted. In fact, to obtain comparable results with a calibration method we would have to use the same population that we used for the original procedure, and test individuals under the same conditions. Calibration of our tuning fork on a small number of laboratory subjects indicates that its characteristic was of the order of 24 db. There is therefore an apparent error of about 7 db. between the two methods of determining the sensitivity of the Rinne test. Our field calibration of the Rinne would take into account the occlusion effect produced by the conductive deafness, but the laboratory calibration would not. The discrepancy can therefore be attributed to the occlusion phenomenon. The effect of the occlusion phenomen is thus to enhance the sensitivity of the Rinne test.

Comments

Our data show that the Rinne test is a valid and reliable test of conductive deafness in excess of 17 db. It is therefore a much more sensitive test than is commonly believed. In view of the fact that the sensitivity of the Rinne test is limited to the detection of conductive deafnesses of greater than 17 db, we feel that this sensitivity can be improved by measuring the time which elapses between cessation of bone conduction excitation and cessation of air conduction excitation, making use of the characteristics of the tuning fork used; e.g. if the decay characteristic of the fork is 1 db. per second for every second of persistence of air conduction excitation after cessation of bone conduction 1 db. should be subtracted from the 17 db. of the hypothetic neutral* Rinne.

Weber Test

We have investigated the response to the Weber test when the footpiece of a 512 c/s tuning fork was applied to the skull in the sagittal plane (*a*) on the forehead, and (*b*) on the vertex. Weber's (1834) original description allowed the fork to be applied to either the teeth or the skull. He said that, with one ear closed, the sound was heard more strongly in the closed than in the open ear. The test is therefore a special application of the occlusion phenomenon (*v.* infra). However, the test is complicated by showing lateralization to the better ear in cases of unilateral, or unequal bilateral, perceptive deafness.

Validity

We have attempted to assess this factor by comparing lateralization in the Weber test with the Rinne response of the 722 ears of a random sample of a rural population. For the purpose of this analysis, lateralization was

* The Rinne response is said to be neutral when the tuning fork is heard as long at the meatus as it is on the mastoid process.

accepted only if there was lateralization to one and the same side when the fork was placed on both the forehead and the vertex. A contingency table is shown in Fig. 2. A χ^2 value of 108·6 is significant at the 0·1 per cent. probability level. This confirms clinical experience that ears which are unequivocally lateralized on the Weber test also tend to give a true unilateral negative Rinne response. There must, however, be the proviso that a unilateral, or an unequal bilateral perceptive deafness, does not exist. Presumably, in the general population, perceptive deafness is a less common cause of lateralization than is conductive deafness.

Rinne response / Lateralization of ear	True negative	Otherwise	Total
Yes	9	25	34
No	4	684	688
Total	13	709	722

FIG. 2.

Contingency table showing correspondence of unilateral true negative Rinne responses and Weber responses on the random sample of 722 ears of a rural population. $\chi^2 = 108·6$ with Yates's correction.

Reliability

We were able, after the elapse of about a month, to repeat the Weber test on 78 unselected individuals in a random sample of a rural population. The test was performed with the foot-piece of the tuning fork on the forehead and on the vertex. These positions were counterbalanced to avoid any "practice" effect. Comparison of the results for the first and second test in the two positions is shown in Fig. 3. The initial results were duplicated in 72 per cent. of cases for the forehead application, and nearly 86 per cent. of cases for the vertex application. The test-retest reliability of the test in the two positions is not significantly different. We can, therefore, conclude that the probability of the Weber giving the same result on a repeat test is about 0·75.

Fig. 4 shows that, in cases where the results of the Weber on both forehead and vertex concur at the first test, replication occurs in about 75 per cent. of cases. Concurrence of the Weber response in both forehead and vertex positions occurs in about three-quarters of a rural population sample.

A. TUNING FORK ON FOREHEAD

FIRST TEST. \ SECOND TEST.	R←	↓	→L	TOTAL
R←	8	6	0	14
↓	7	41	3	51
L→	2	4	7	13
TOTAL	17	51	10	78

B. TUNING FORK ON VERTEX.

FIRST TEST. \ SECOND TEST.	R←	↓	→L	TOTAL
R←	4	6	0	10
↓	4	55	3	62
→L	0	3	3	6
TOTAL	8	64	6	78

FIG. 3.

Tables showing the test-retest reliability of the Weber test when a 512 c/s tuning fork is applied (*a*) to the forehead, and (*b*) to the vertex.

Weber Response \ Replication on second test	Yes	No	Total
R ←——	3	1	4
↓	37	10	47
——→ L	3	3	6
Total	43	14	57

FIG. 4.
Table showing test-retest reliability of Weber test where there is concordance between result obtained with tuning fork on forehead and that obtained with tuning fork on vertex.

Sensitivity

The Table in Fig. 2 shows that about a quarter only of the ears that are lateralized in the Weber test also give a true negative Rinne response. This might be attributed to two factors:

(i) The tendency of the Weber to lateralize also in unilateral, or asymmetrically bilateral, perceptive deafness and/or

(ii) The possibility that the Weber is a more sensitive test of conductive deafness.

Half of the ears that were lateralized also showed other evidence indicative of a lesion of the sound conducting apparatus, but in only three cases was there evidence of a contralateral perceptive deafness. We therefore conclude that the Weber is a more sensitive test of conductive deafness than the Rinne. In clinical practice, with a population different from the one considered here, the complication of a possible perceptive deafness may make the interpretation more difficult.

Comment

The data indicate that the Weber test perhaps attains an acceptable level of reliability, but it is too sensitive. Rubinstein and Klein (1957) used an audiometer to do the Weber test. They found that individuals with an "air-bone gap" of as little as 5 db. could lateralize correctly and easily. This degree of sensitivity might be expected if we consider the Weber test as a special case of the occlusion phenomen (*v.* infra). However, the complication introduced by a perceptive deafness influences the interpretation of the validity of the test. Rubinstein and Klein contend that it is possible to predict not only the direction of lateralization of the Weber test but also its intensity. These authors present a formula which

involves considering the side with the lower bone conduction threshold and the side with the greater "air-bone gap". Using their formula, they were able to predict the audiometric Weber test correctly in 75 per cent. cases at 500 c/s. and 85 per cent. cases at 100 c/s.

Occlusion Test

When the foot piece of a vibrating low frequency tuning fork is applied to the mastoid process of a normally hearing observer, the loudness of the perceived sound is increased by occluding the corresponding external auditory meatus. This is known as the occlusion phenomenon and was first described by Wheatstone (1827) and by Tortual (1827). Later, Bing (1891) introduced the test into clinical otology. He prescribed a tuning fork of "medium strength and tone", placed on the skull either in the sagittal plane or on the mastoid. When the sound dies away, Bing said that it will be heard again for a certain time when the meatus is gently occluded by the index finger. If it is not, then there is interruption of sound conduction due to a middle-ear affection.

We have found it more convenient to do the test with an audiometer, using the bone conduction transducer in lieu of the tuning fork. By this means the test becomes quantitative, and comprises, in effect, a determination of the two bone conduction thresholds: the so called absolute threshold (external auditory meatus occluded) and the relative threshold (external auditory meatus open).

Validity

Kelley and Reger (1937) showed that the occlusion effect was the same whether the bone conduction transducer was on the forehead or on the mastoid. In French audiologic practice, it is customary to perform the occlusion test with the transducer on the forehead (Aubry, 1945); Naunton (1957) has again recommended this procedure for a variety of reasons. Naunton also advocates the use of the air-conduction receivers of the audiometer as the occluding device. It appears that earphones might give a larger occlusion effect than that obtained by the use of a plug or the finger tip. This will enhance the discriminating power of the test. Using this procedure, Naunton showed that, with respect to the magnitude of the observed occlusion effect, ears which had otoscopic evidence of lesions of the sound conducting apparatus also had the same distribution as otosclerotic ears. The modal occlusion effect for both these conditions was 0 db. for test tone frequencies ranging from 250 to 4,000 c/s. Other ears (normal and perceptively deaf) showed distributions that were significantly different at 250 c/s and 500 c/s only, where the modal occlusion effect was 15 db. Lierle and Reger (1946) also said that the occlusion phenomenon was only demonstrable under about 1,500 c/s.

At 250 and 500 c/s, there was no appreciable overlap between Naunton's distribution curves for conductively and non-conductively deaf ears. The point of intersection of the two curves was about 5 db. We can, therefore conclude that the occlusion phenomen (or, rather, its absence) provides a valid test to distinguish conductive deafness at audio-frequencies of 250 c/s and 500 c/s.

Reliability

Preliminary measurements indicate that the test-retest reliability of the occlusion test may not be as high as the more conventional audiometric tests.

Sensitivity

Examination of Naunton's data shows that the occlusion phenomenon appears to be an "all-or-none" effect, and is, moreover, abolished by minimal degrees of conductive deafness. In fact, otoscopic evidence of lesions of the sound conducting apparatus may be present in the absence of a demonstrable shift in the threshold audiogram, yet the occlusion phenomenon has been abolished. We have examined one case of suspected otosclerosis where the Rinne test was positive and the "air-bone gap" was 5 db. at 500 c/s. The occlusion test, however, was negative. We have not yet examined an ear that has given a Rinne negative response and that has not also given a negative occlusion test. This is what one would expect in view of the Rinne test becoming negative only when the degree of conductive deafness has attained 17 db.

The degree of the occlusion effect is not proportional to the degree of conductive deafness. Indeed, with increasing degrees of deafness the occlusion effect seems to decrease slightly.

Comment

When done with an audiometer, the occlusion test appears to be the most sensitive and valid test of conductive deafness. As Lierle and Reger (1946) say, slight middle-ear involvement in which the air conduction acuity shows but little loss, is sufficient to result in a negative occlusion test.

Combined Air and Bone Conduction Audiometry—The "Air-Bone Gap"

Validity

Békésy (1932) early pointed out that stimulation of the ear by bone conduction has the same cochlear mechanism as stimulation of the ear by air conduction. It is not uncommonly considered that the bone conduction threshold indicates the degree of cochlear function and that

the difference between the air and bone conduction threshold is a direct measure of the degree of conductive deafness. However, clinical bone conduction thresholds involve three pathways:

(1) Compressional bone conduction (Herzog and Krainz, 1926).
(2) Inertial bone conduction *viâ* the ossicular chain (Bárány, 1938).
(3) Air conduction *viâ* the external auditory meatus and the, subsequently, normal air conduction pathway (Békésy, 1932).

It should, therefore, be possible for affections of the external or middle ear to influence the clinical bone conduction threshold. Thus in otosclerosis, for example, the conventional bone conduction audiograms may show:

(1) Enhanced low frequency acuity due to the occlusion phenomenon (Rytzner, 1954).
(2) A mid-high frequency notch due to the stapedial ankylosis (Juers, 1948; Groen, 1949; Carhart, 1950).
(3) An increasing loss of acuity with rising frequency, due to combined oval and round window block (Groen and Hoogland, 1958).

Moreover, after fenestration, there may be enhanced acuity for bone conduction due to the increased driving force of the functionally lengthened scala vestibuli (Ranke and Lullies, 1953; Groen and Hoogland, 1958).

These factors must, therefore, be considered when assessing the "air-bone gap" in audiograms of otosclerotic, or other conductively deaf, ears. Combined oval and round window block is uncommon and will present as a bone conduction curve having a fall of about 6 db./octave, because of the acoustic leaks of the cranio-tympanic channels (Groen and Hoogland, 1958). In general, therefore, one need correct only for the occlusion effect and the so-called Carhart's notch. Considering the data of Carhart (1950), Rytzner (1954) and Naunton (1957) one should add, to the unoccluded bone conduction audiogram, 10 db. at 250 c/s, 0 db. at 500 c/s, −5 db. at 1,000 c/s, −20 db. at 2,000 c/s and −15 db. at 4,000 c/s. Provided appropriate masking has been employed, the gap between the air conduction audiogram and the corrected ipsilateral bone conduction audiogram will be a valid measure of the degree of conductive deafness.

Reliability

The reliability of the "air-bone gap" resolves itself into the reliabilities for the two procedures, air conduction audiometry and bone conduction audiometry. The test-retest reliability of air conduction audiometry is of the order of 0·85 (Burns and Hinchcliffe, 1957) and that of bone conduction audiometry is comparable to air conduction audiometry (Carhart and Hayes, 1949). One must, therefore, conclude that combined air and bone conduction audiometry forms a reliable measurement of conductive deafness.

Sensitivity

The standard deviation of the air conduction threshold for a random sample of young normal ears ranges from 5·4 to 6·4 db for the frequency 250 to 4,000 c/s. The corresponding standard deviation of the bone conduction threshold for a sample of young normal ears ranges from 6·5 db. to 7·4 db. (Greenbaum *et al.*, 1939). Moreover, the correlation between the air and bone conduction thresholds of normal ears falls from 0·41 at 4,000 c/s to 0·20 at 250 c/s (National Health Survey 1935-6, Hearing Study Series Bulletin No. 4, 1938) although Roach and Carhart (1956) found a higher correlation (0·48 to 0·76) in this frequency range. These authors also found the standard deviations of the normal air and bone conduction thresholds to be less than those quoted above. Unfortunately, it is precisely at the lower frequencies that conduction deafness first presents, and where, therefore, tests for this are required to be the most sensitive.

Comments

In view of the extent of the range of both normal air and of normal bone conduction thresholds and the possible poor inter-dependence, it is not surprising that some otologists consider threshold audiometry to be less sensitive than tuning fork tests in the detection of conductive deafness. It will be recalled that the Rinne test was shown to be sensitive to conductive deafnesses of less than 17 db.

An increased resolving power of threshold audiometry may be obtained by employing continuously recording procedures. Such methods would increase the sensitivity of combined air and bone conduction audiometry in the detection of conductive deafness. In current clinical practice, however, much of the uncertainty regarding the significance to be attached to small "air-bone gaps" is directly related to three factors appertaining to the bone conduction threshold:

(1) What is the reference zero of the bone conduction measurement of the threshold?
(2) Is the ambient noise level in the test situation insufficient to mask the measured threshold? and
(3) Was appropriate masking of the contralateral ear employed?

Since artificial mastoids (analogous to artificial ears) are not yet generally available, objective calibration of bone conduction transducers cannot be performed in the same manner that we can calibrate earphones. The reference zero of the bone conduction audiogram must therefore be obtained by subjective methods. The method advocated by Roach and Carhart (1956), using individuals with pure sensorineural hearing losses, is convenient. A continuous check on the calibration of the bone transducer should be made by monitoring its voltage input.

The maximum permissible noise levels for bone conduction audiometry are appreciably less than those for air conduction audiometry, where we have extra acoustic insulation provided by the receivers and their cushions. Maximum permissible noise levels in the various octave bands may be calculated from Hawkins and Stevens' (1950) data on the masking of pure tones by noise.

Since a bone conduction transducer stimulates the skull as a whole, there may be little or no sound attenuation across the skull. Moreover, since there are regions of minimal and maximal amplitude existing in the vibrating skull, normally hearing individuals may consistently hear a bone conduction receiver in the contralateral ear (Spoor *et al.*, 1957). Consequently, masking is usually required in bone conduction audiometry. Exceptions may occur when there is unequivocal lateralization. In severe conductive deafness, the application of masking by an external receiver will frequently be impossible since such masking starts to mask the other ear (i.e. ear under test) when the masking level exceeds about 45 db. A greater inter-aural attentuation is achieved by use of an insert receiver. This will enable masking levels of up to 80 db. (less the occlusion effect) to be achieved before "cross hearing" occurs (Littler, *et al.*, 1952). If, in the determination of the air conduction thresholds in suspected pure conductive deafnesses, cross-hearing of the test tone is suspected, masking of the ear not under test can only be done with an insert receiver.

The Rinne test forms a quick, simple, valid and reliable screening test for conductive deafness. A conductive deafness of only 17 db. severity can be detected by the Rinne response. The most sensitive test of conductive deafness, however, is provided by the occlusion phenomenon. Provided that strict attention is paid to technique, combined air and bone conduction threshold audiometry is a reliable measure of the degree of conductive deafness, bearing in mind the influence that middle-ear lesions may have on the bone conduction threshold itself. Complicated masking procedures may be required in the measurement of severe conductive deafnesses.

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RECRUITMENT AND PER-STIMULATORY FATIGUE IN DIAGNOSIS

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THE increasing knowledge of cochlear and vestibular physiology compels the present-day otologist to improve and refine his functional tests with a view to arriving at a more definite localization of the lesion. This need has become obvious especially in the field of audiology, in which workers with a widely varying education have tried to contribute to more reliable diagnosis.

Unfortunately, however, several of the great number of tests proposed for the classification of hearing impairments into definite sub-groups have not stood the test of critical appraisal. It is therefore no wonder that distinguished clinical otologists hold little faith in some of the tests performed and interpreted by audiologists without clinical background (Fowler, 1952, Lempert, 1953). Many of the bizarre and irregular results obtained in the elaborate tests may depend on entirely secondary and irrelevant factors, and may not even be reproducible in the same patient. Otologists in general, therefore, utilize the air and bone conduction tests as well as speech audiometry supplemented with tests for loudness recruitment phenomenon in their clinical work.

In the Symposium on the assessment of auditory function held at the International Conference in Audiology in St. Louis, in 1957, I had the opportunity of discussing the audiological diagnosis of cochlear v. retrocochlear lesions. It was concluded that at the time we did not have such audiological tests as would differentiate the two lesions with 100 per cent. certainty, although some of the tests are of definite help in diagnosis. For further details the reader is referred to this earlier paper (Palva 1958).

In the present paper I wish to discuss some characteristics of the recruitment phenomenon and examine its form in various clinical groups of deafness. The appearance of per-stimulatory fatigue in self-recording audiometry will be dealt with in more detail, as its appearance has lately also been linked to certain specific sites of lesions in the auditory apparatus.

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Recruitment and Per-Stimulatory Fatigue

Clinical Differentiation between Conductive and Perceptive Deafness

The routine audiological differentiation between conductive and perceptive hearing impairments is made on the basis of air and bone conduction audiometry. In the majority of cases the difference is clear cut, cases with good bone and poor air conduction representing typical conduction deafness.

The first observations of lowered bone conduction in true conduction deafness go back to the early part of this century, although the findings were forgotten for many decades. Rejtō (1914) is credited by Krainz as having already mentioned that impaired mobility in the labyrinthine windows must result in lowered bone conduction, which therefore is not always indicative of a true perceptive lesion. Krainz (1926, 1927) mentions several conditions in which impaired bone conduction occurs in conduction deafness, viz. otosclerosis with bony overgrowth on the round window membrane, tubal occlusions, and fluid in the middle ears.

These pioneering results were obtained with time-consuming tuning fork tests and it is no wonder that they received no wider attention. In the audiometric era with its simple and quick bone conduction test, the lowered bone threshold in conduction deafness was rediscovered. Carhart (1950) showed, in a series of otosclerotic patients that after re-establishment of the labyrinthine pathways, the bone conduction values would increase from 5 to 15 db between 500 and 4,000 cps. Palva and Ojala (1955) demonstrated, in a series of 42 ears with acute or catarrhal otitis and fluid in the middle ears that 15 (36 per cent.) showed a clear reduction of initial bone conduction thresholds, which improved as the ears became dry and the labyrinthine windows could again move freely.

Recently, in a series of chronic, operated ears, we (Palva and Pulkkinen, 1960) were able to show that, even in these longstanding cases, the bone conduction thresholds are mechanically lowered and do not represent real perceptive loss. Thus, in cases treated with radical operation and window plasty, bone conduction thresholds (average of 500, 1,000 and 2,000 cps) improved more than 10 db in 36 cases or 32 per cent.

We concluded that in these cases of hearing impairment the lowered bone conduction values do not necessarily indicate a true perceptive deafness but are due to impaired mobility at the oval and round window. We also recommended that speech intelligibility studies be made in these cases because good articulation scores would favour a conductive lesion and lowered intelligibility a true perceptive hearing loss.

In differentiating conductive hearing loss from perceptive impairment, the clinical otologist is in a much better position than the audiologist to interpret the cases correctly. He has at his disposal information on the tympanic membranes and can use Siegle's speculum to see if the middle ear is free of disease. If the tympanic membrane is fixed, if there are granulations in the middle ear or some other pathology involves the

window regions, then a lowered bone conduction with good speech score is no contraindication for hearing restoring operations.

Recruitment and Perceptive Deafness

When E. P. Fowler, Senr. noted (1936) that the increase of perceived loudness was disproportional to the increment of physical intensities of the stimulating tone, he described this as a loudness recruitment phenomenon which he thought was pathognomonic of perceptive deafness. Twelve years later, Dix, Hallpike and Hood (1948) reported on a series of cases of Ménière's disease on one hand, and a group of patients with acoustic neurinoma on the other hand, stating that these two groups differed widely in their response to loudness recruitment tests. They concluded that complete loudness recruitment characterizes cases with inner-ear lesions while the absence of recruitment denotes retrocochlear pathology. This classification of pathology according to recruitment tests has been subject to numerous experiments and active discussion in oto-audiological circles.

The subject of relating the loudness function to ear pathology has been discussed more comprehensively earlier (Palva, 1958). It was concluded that the present evidence favours the idea that a pure hair cell lesion is associated with loudness recruitment and a pure nerve fibre or ganglion cell deafness is not. In many cases, however, the lesions are combined and recruitment may or may not be present; especially in cases with a longer history and increasing deafness, the initially positive recruitment may become incomplete or disappear wholly.

The origin of the recruitment phenomenon has not become clear although many new facts about inner-ear physiology are constantly being discovered. It seems that the old hypothesis of Lurie (1940), advanced 20 years ago is still the most probable one. Lurie reasoned, that the recruitment function, which becomes evident at higher intensities, depends upon the integrity of the internal hair cells; these are not stimulated with lower intensities and generally remain intact even if the greater part of the external hair cells have been damaged. This theory has also been independently proposed by Tumarkin (1954).

The observation made by Saxén (1938) as regards the integrity of nerve fibres on the basilar membrane might throw added light to the understanding of the recruitment phenomenon. Especially in cases where the external hair cells were missing, but also in those where both external and internal cells were missing in a restricted area, there appeared a reversal of the Weber test at higher intensities—a fact we know can be accepted as an indication of positive recruitment. It might well be that the nonmyelinated (and noninsulated) nerve fibres would pick up electrical impulses from the adjoining areas even with a locally reduced number of internal hair cells.

Recruitment and Per-Stimulatory Fatigue

In recent years the finding of summating potential by Davis and his associates (1958), interpreted as being due to the excitation of the inner hair cells, has also been looked upon as corroborative evidence of the nature of the recruitment phenomenon. In typical recruiting deafness such as acoustic trauma, the cochlear potentials, thought to represent mainly the activity of the external hair cells, show in their lowered total intensity a curve typical of nonrecruiting deafness; the summating potential, however, remains unaltered and comparable to its value in normal ears.

It is noted in this connection, that Hallpike and Hood (1959) have quite recently altered their own view of the origin of the loudness recruitment to conform with the hypotheses of Lurie and Davis.

Material and Method

The material studied in this work consists of cases examined and followed during the last three years both in my private office and in hospital wards. The prerequisite for admission into the series was that the tympanic membranes and middle ears were normal and the bone conduction equalled air conduction in the audiograms. It was further demanded that the contralateral ear was normal or near normal, although a few cases with definitely known pathology were included with hearing loss in both ears. The total number of cases observed, many of them repeatedly, amounts to 98; in some cases several frequencies were tested.

The recruitment function was determined by the ordinary method using interrupted 1·5 secs. long tones alternately in the ears at different sensation levels. Conclusions were drawn as to the nature of the recruitment function on the basis of only those cases in which the other ear was normal or near normal (less than 20 db loss). In cases with unequal bilateral loss, the result would naturally be affected by the loudness function in the depressed better ear, which would render the curves obtained incomparable to normal.

No masking was used in this test, even if the poorer ear was depressed considerably below the 50 db level. If loudness recruitment appears in these cases, then the loudness sensations in both ears become equal at high intensities; if there is no recruitment, then the final difference between the ears will never be less than 40-50 db, the amount lost in interaural attenuation (Palva, 1954).

The tests for per-stimulatory adaptation were made using self-recording audiometry by letting the patient record his threshold at a fixed frequency during a four-minute test period. The technical data of this procedure have been described in earlier papers (Palva, 1956, 1957). However, in contradistinction to recruitment testing, the use of masking is imperative in these tests if threshold difference between the ears exceeds

40 db. White noise with a broad spectrum was employed as masking stimulus, and applied according to the principles described earlier (Palva, 1954, 1958a).

Recruitment function in Different Clinical Categories

The objective tests have included routine audiometry for pure tones and speech as well as determination of the recruitment function and per-stimulatory threshold adaptation. In most vertiginous patients hot and cold caloric tests according to Fitzgerald and Hallpike (1942) were performed; signs of corneal and cheek anæsthesia, of spontaneous nystagmus and of cerebellar symptoms were sought for. In a good number of cases X-rays of the internal auditory meatuses were obtained, and the cerebrospinal fluid pressure and protein content were determined in all cases suspected of having an acoustic neurinoma.

The cases seen and followed during the observation period were classified into 12 main groups on the basis of anamnestic and clinical data. The appearance of an asymmetric, straight line or incomplete recruitment as well as the absence of recruitment is indicated in Table I. The data for each case are, as far as possible, derived from a frequency showing normal contralateral ear, and when several frequencies were tested, the overall outcome is shown in the table.

TABLE I.
CLASSIFICATION OF CASES

Diagnosis	Recruitment Function				Total
	Asymmetric	Straight line	Incomplete	None	
Ménière's disease ..	5	11	7	1	24
Cochlear degeneration	5	11	—	—	16
Nondefined vertigo	1	3	6	2	11
Presbyacusis ..	2	2	5	—	9
Acoustic trauma ..	4	3	2	—	9
Skull trauma ..	—	2	3	—	5
Toxic lesion ..	1	4	—	2	7
Vascular accident..	1	—	4	1	6
Heredo-degenerative deafness ..	—	—	—	3	3
Central lesion ..	4	—	—	1	5
Acoustic tumour ..	—	—	—	2	2
Multiple sclerosis ..	—	1	—	—	1
TOTAL					98

The classification is in most groups self-explanatory: the headings cover cases in which the clinician does not meet any special difficulties. A few explanatory words, however, are necessary to clarify the composition of certain diagnostic groups.

Recruitment and Per-Stimulatory Fatigue

The group of cochlear degeneration consists of patients showing perceptive deafness with no vestibular signs and with a positive recruitment phenomenon. The latter has thus been the decisive factor in classifying the group, although no definite topographic localization is implied.

The group of nondefined vertigo is a heterogenous one consisting of patients who at some stage of the disease had vertiginous attacks but whose disease did not show the characteristics of Ménière's disease. The group includes cases with both peripheral and central vestibular disorders with hearing loss.

Ménière's disease. The 24 cases observed in this group presented all the typical symptoms and signs of Ménière's disease. All of them had undergone several periodic tests; in some, the records extend over several years. About half of the present records are tests performed while the patients were hospitalized during acute exacerbations of the disease. In the other half the symptoms had been absent for a period of time, sometimes for many years, the hearing loss being the only subjective sign at the examination.

Sixteen cases, or 67 per cent., showed complete recruitment, mainly in the form of a straight line function. In seven cases the loudness equality remained incomplete, the final difference between the ears being from 10 to 35 db. In one case the initial difference of 60 db decreased to 40 db, but as pointed out above, it can be regarded as the outcome of cross-hearing.

Figure 1 presents these 8 cases with incomplete or absent recruitment, tested at 13 frequencies. In one of those cases a complete equality was reached at 60 db setting, but at higher sensation levels the better ear heard the tones with 15 db preference to the poorer ear. In all other cases, the poorer ears remained definitely poorer at all levels, in spite of some recruitment.

All these cases were tested during the quiescent state of the disease; in two there had been neither vertigo nor fluctuation in hearing for 4 years.

Presbyacusis. In accordance with the work of Saxén (1938), the two most important histological types of presbyacusis are the angiosclerotic and nerve degeneration type. The patients included in this study showed clinical evidence of generalized arteriosclerotic disease and there is no reason to suppose that the labyrinthine vessels had been spared by this process. Recruitment was complete in Regers test in 4 cases and incomplete in 5.

Acoustic trauma. Care was taken that all cases included in this group were free of any associated middle-ear lesion. In 7 cases the injury was due to gunfire, in 2 to continued work in a factory with a high noise level. The recruitment phenomenon was complete in 6 cases of the former and one of the latter group, and incomplete in the remaining 2 cases.

Skull trauma. Five patients from a larger group of cases were included

in the study; these had no complications in the middle ears. All five complained of hearing loss after the head trauma, and it was found to be of perceptive type. Recruitment was complete in 2 and incomplete in 3 cases.

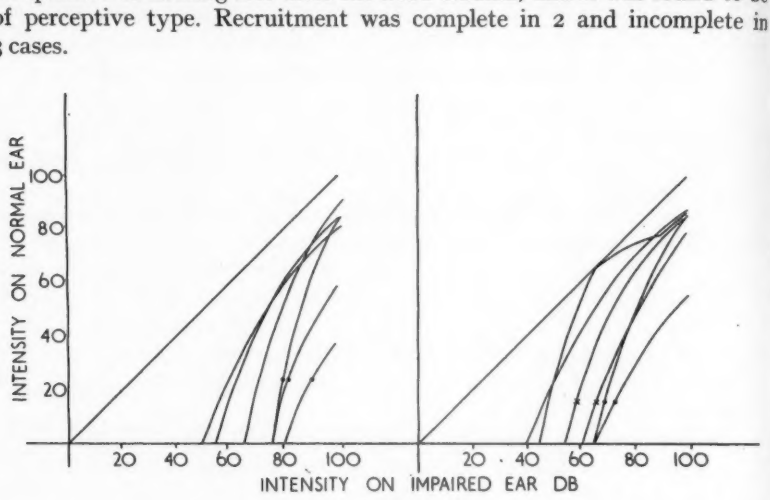

FIG. 1.

Recruitment function in 8 cases of Ménière's disease tested at 12 frequencies. In all, the final difference between the ears at 100 db setting is 15 db or more. The curves marked with dots or crosses represent a single case tested at several frequencies.

Toxic lesions. A toxic lesion due to streptomycin appeared in 4 cases, all cases associated with recruitment. One case had partial deafness following typhoid fever; in this case there was no recruitment. One case was attributed to infected tooth rootlets in the upper jaw; recruitment was present. Improvement of hearing and of vestibular symptoms followed rapidly after removal of the focus. In the last case with no recruitment the hearing loss was attributed to prolonged use of salicylates.

Vascular accident. In 6 patients there was a definite history of a major labyrinthine vascular accident. The hearing loss appeared suddenly, generally accompanied with severe vertigo, which subsided in a few days. Audiometry showed a severe 50-60 db hearing loss combined with canal paresis. Recruitment was complete in one of these cases, incomplete in 4, and absent in one case. (It should be stated that we have observed many other cases of vascular accident leading at least initially to nearly total deafness; these cases were not included as direct tests of recruitment were impossible.)

Central lesions. This group is made up of 5 cases in which the clinical diagnosis was centrally located disease. As knowledge of the symptoms is here of greater importance, somewhat more data are given for each case.

Case I. Severe encephalitis with disorientation of 3 months' duration accompanied by left glossopharyngeal and vagal palsies. At the time of the hearing tests, hearing had already begun to improve; there was, however, a bilateral U-shaped loss of 20-40 db between 500 and 2,000 cps. At 4,000 cps the right ear was normal and the left had 35 db loss; Fowler's test showed complete, asymmetric recruitment.

Case II. The patient had undergone hypophysectomy two years previously because of failure of operative and radiation treatment of her mammary carcinoma. Her condition improved greatly; at present a hearing loss developed in the left ear with associated tinnitus and vertigo and complete left-sided hypoglossal paralysis. The clinical data point to metastasizing carcinoma. The result of hearing tests are shown in Fig. 2.

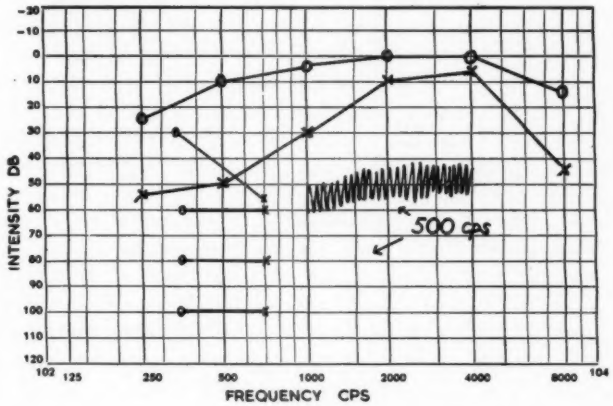

FIG. 2.

An audiogram of a case with a centrally metastasizing mammary carcinoma. The horizontal lines show complete recruitment beginning at 60 db setting. The 4 minute threshold test shows large excursions and no fatigue.

Case III. The patient had a cerebral hæmorrhage 13 years previously at the age of 45 years. Hearing loss in the left ear appeared simultaneously and has remained stationary at the 50 db level. The mobility of the limb and trunk muscles on the right side has returned to almost normal. A left-sided trigeminal paresthesia, is still present, and also spontaneous nystagmus to the left and directional preponderance in the caloric tests to the same side. At times the patient experiences attacks of vertigo. Fowler's test at 1,000 cps showed complete, asymptotic recruitment. Speech intelligibility in this ear was 0 per cent.

Case IV. The patient was operated on for a left sided glioma at the age of ten years, in 1940. In addition to some other, mainly visual defects, a 50-60 db hearing loss has since been stationary in the left ear. Fowler's test at 2,000 cps showed complete asymptotic recruitment.

Case V. Tinnitus and hearing loss of about 60 db were noted in the left ear for three months. There is an associated trigeminal paresthesia and a hypoglossal palsy on the same side. The etiology of this lesion is still unknown. Fowler's test was made at 4,000 cps and it showed no recruitment.

Comment

At the present time enough histological data are available on some of the clinical groups for classifying the lesion anatomically. Thus, of the groups included in Table I, the cases with Ménière's disease, acoustic trauma and toxic lesions due to streptomycin, can be included in the group of end-organ damage, at least in the fresh and uncomplicated cases.

Of the 37 cases in the above three groups, 27 cases, or 73 per cent., showed complete recruitment. In 9 cases recruitment was incomplete, the final intensity difference varying from 10 to 35 db. In one case of Ménière's disease there was no recruitment.

In the other diagnostic groups, the main pathology in central lesions, in acoustic tumours, and in multiple sclerosis evidently is outside the end-organ. Complete equality of loudness was reached in four cases with central lesions while one showed no recruitment. Both cases of acoustic tumour had no recruitment, although the hearing was so much depressed in one that enough balancing levels could not be obtained. The case with multiple sclerosis had a recruiting hearing loss at 4,000 cps.

Skull trauma, presbyacusis, toxic auditory lesions in part, vascular accidents and heredo-degenerative diseases are known to affect both the hair-cells and ganglion cells or nerve fibres, and it is difficult without autopsy data to determine what particular parts are affected in each case. Recruitment is seen to be present in the majority of the cases; in many cases it is incomplete, and in some absent.

It might be argued that even incomplete recruitment should be considered indicative of end-organ pathology while the difference in equality would represent the nerve component. However, since many cases of definite retrocochlear pathology show even complete recruitment, it does not seem feasible to make such a rigid division—all the more as in typical end-organ lesions recruitment may be absent, notably in older and stabilized patients with Ménière's disease.

This category of patients was also noted by Kos (1955) to show no recruitment, but his conclusions were based on a self-recording audiogram. It has been pointed out (Palva, 1957) that large excursions do not necessarily indicate the absence of recruitment, which may be complete in Fowler's test.

Thiébaut *et al.* (1955) reported on three cases of central lesions accompanied with recruiting deafness. They postulated that, although the lesions were clearly outside the cochlea, they might cause some disturbance in the end-organ due to circulatory disturbances or *viâ* the

afferent nerve fibres; thus the localizing value of the recruitment phenomenon would not be violated. The same explanation could naturally be extended to the present 4 recruiting central cases, but the fact remains that the whole clinical evidence places the disturbances centrally.

Cases with acoustic neurinoma generally present the absence of recruitment, and indeed, it was on the basis of this finding that Dix, Hallpike and Hood (1948) suggested the localizatory value of the recruitment phenomenon. Fowler, Senr. (1950, 1952) later presented two cases of acoustic tumour with recruitment: additional similar cases have been reported, e.g. by Goodman (1957) and the present author (1958). Dix and Hood in their later studies (1953) found that recruiting cases of neurinoma accounted for about 12 per cent. of the total. This they ascribed to the circulatory disturbances caused by the tumour upon the end-organ.

On re-examination of the data presented in Table I, one might be tempted to agree with the pioneer in the field of recruitment tests E. P. Fowler, Senr., who still holds his original opinion, viz. that the recruitment phenomenon appears in perceptive deafness in general—but not necessarily in every case—and that it is not pathognomonic of any specific site of the lesion.

As long as the concepts of the precise origin of the recruitment phenomenon are not definitely clear, it seems wise not to be too certain regarding the information obtained from recruitment tests. Further difficulties arise if Lurie's hypothesis confirmed with Davis's electrophysiological data prove to be the best explanation. Then only the external hair cell lesions associated with intact internal hair cells would cause recruitment, while lesions affecting both cell groups, although still strictly limited to the end-organ, would produce no recruitment.

Clinical experience proves, however, that complete recruitment is generally associated with disease groups with end-organ lesions and its absence with cases of nerve degeneration. One should use the recruitment tests as additional evidence in certain diseases, but they should not be given a decisive rôle in determining the diagnosis or treatment. We need only remember the cases with central pathology in which the clinical evidence unquestionably localizes the lesion outside the end-organ. It would not be wise to insist unconditionally that the pathology lies in the cochlea. A complete oto-neurological examination including recruitment and other audiological studies is needed in the examination of these cases.

Disregarding the clinical side of the question, the absence or presence of recruitment is always of great importance in determining the ear's capacity to handle sounds notably speech. We need only think of the use of hearing aids in these two categories to appreciate their different characters. It therefore seems wise to divide perceptive deafness, whenever possible, into recruiting and non-recruiting groups and make the

localization with the help of additional anamnestic and combined audiological and clinical data.

The Appearance of Per-Stimulatory Fatigue

In studying the width of the threshold tracings and their slope in the four minute self-recording test, all groups included in Table I were utilized. The results are presented in Figs. 3 and 4 respectively. The average width of the tracings is plotted as a function of frequency in various recruitment groups in Fig. 3. It is seen that at the middle and low frequencies the marks, even in recruiting deafness, are very often above the 5 db division line, and thus no conclusions can be drawn as to the presence or absence of recruitment. At higher frequencies the correlation becomes much better, a finding which agrees well with the data reported earlier (Palva, 1957).

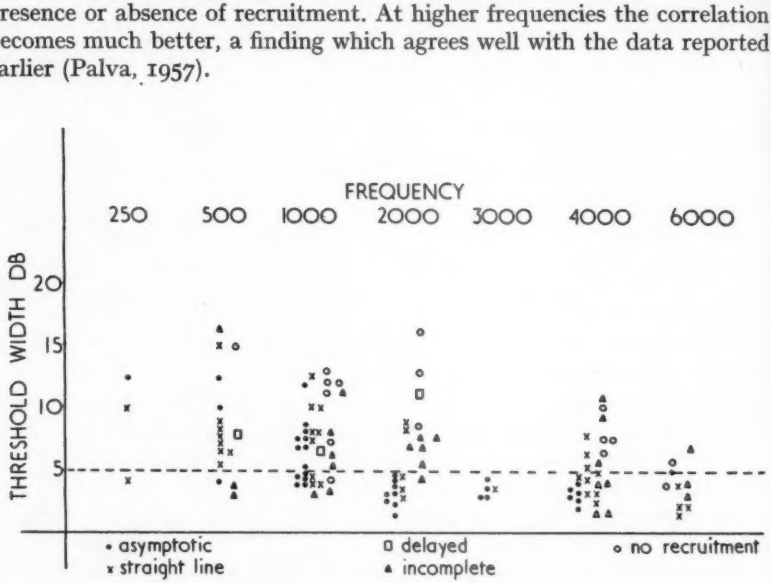

FIG. 3.

The width of the threshold variability related to the frequency in various groups of recruitment. The tracings become clearly smaller with increasing frequency, and at the higher tones there is a good parallelism between small tracings and complete recruitment.

Fig. 4 illustrates the changes in the course of the tracings at the end of the four minute recording period as related to the different recruitment functions. The dots above the baseline indicate an improvement of the threshold during the test, the dots below show the amount of fatigue. The number of frequencies tested in the 98 patients is 127.

The general impression gained from Fig. 4 is that the majority of cases in each separate group show a ± 5 db shift, which is entirely within

normal limits. On the other hand, several groups include cases in which the fatigue experienced during the tests is clearly abnormal, viz. over 10 db. This finding also agrees well with the experience recorded earlier (Palva, 1957).

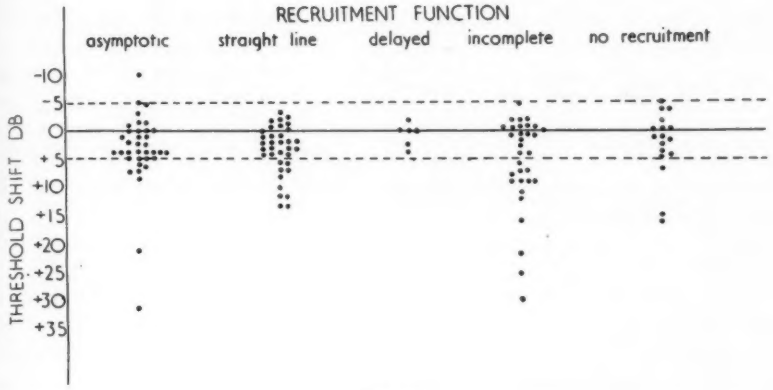

FIG. 4.

Per-stimulatory threshold shift at the end of 4 minutes' stimulation related to recruitment function. The majority of the values lie between 5 db lines, but there are altogether 15 instances in which the per-stimulatory fatigue exceeds 10 db.

For a more detailed study of the cases with abnormal fatigue Table II is presented, which relates the clinical categories to various other data. In a total of 15 cases the per-stimulatory fatigue exceeded 10 db; the maximum was 32 db. The Table gives individual data on the recruitment function, the threshold width, and the frequency tested.

Although many of the patients presented in Table II were tested at two or three different frequencies, the maximum fatigue appeared at the frequency presented in the Table. In some cases there was no fatigue at the other frequencies; in others the tracings showed deterioration of threshold but not to such a degree as at the frequency presented in Table II.

It can be seen that abnormal per-stimulatory fatigue appears between 500 and 6,000 cps. It was not possible to observe any clear relation between the amount of fatigue and the frequency tested. Most of the frequencies in the Table are at the high end but this is due mainly to the fact that these frequencies were used more often than the lower tones.

Fig. 5 presents the results of per-stimulatory fatigue tests in four cases of varying pathology; case "a" is a patient suffering from acoustic trauma with asymmetric recruitment. Case "b" is a patient with Ménière's

TABLE II.

CASES WITH ABNORMAL PER-STIMULATORY FATIGUE

Diagnosis	No. of Cases	Recruitment	Amount of Fatigue db	Threshold width db	Testing Frequency
Ménière's disease	6	Complete	21	2–5	2,000
		Complete	13	2–3	2,000
		Complete	13	8–15	1,000
		Incomplete	12	4–9	2,000
		Incomplete	30	1–2	4,000
		Incomplete	11	5–9	2,000
Nondefined vertigo ..	3	Complete	11	2–4	4,000
		Complete	11	8–10	2,000
		Incomplete	11	5–9	2,000
Cochlear degeneration ..	1	Complete	14	1–2	6,000
Acoustic trauma	1	Complete	32	2–4	2,000
Skull trauma	1	Incomplete	22	2–5	4,000
Vascular accident ..	1	Incomplete	25	6–8	1,000
Heredo-degenerative deafness..	1	Absent	15	6–8	2,000
Acoustic tumour	1	Absent	16	10–15	500
Total	15				

disease showing incomplete recruitment and case "d" an acoustic tumour with no recruitment. Curve "c" represents a patient with heredo-degenerative disease and no recruitment.

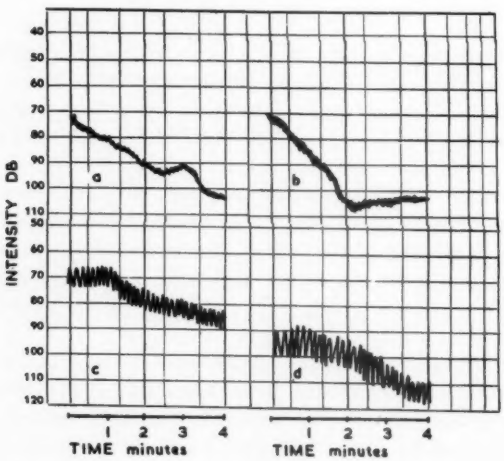

FIG. 5.

Abnormal per-stimulatory fatigue in four cases with different pathology: (*a*) a case with Ménière's disease and (*b*) an acoustic trauma, both with complete recruitment: case (*c*) has heredo-degenerative deafness, and (*d*) an acoustic tumour, the last two without recruitment.

Comment

The early findings with regard to per-stimulatory adaptation, viz. the data of Hood (1950) and of Reger and Kos (1952), showed that abnormal fatigability is found both in recruiting and non-recruiting perceptive deafness. This was also confirmed by the author's experiment (1957); it was further demonstrated that in neither group is fatigability common: the standard response is a tracing showing a steady course.

Hood later (1955) reached the conclusion that abnormal fatigability is a phenomenon characteristic of recruiting deafness and end-organ disease, while Kos (1955) supports the opposite view, viz. that non-recruiting nerve cases are especially susceptible to per-stimulatory fatigue. A few individual cases have later been added to the latter group: thus Jerger *et al.* (1958) and Yantis (1959) found abnormal fatigue to appear in a total of 5 cases of acoustic nerve tumour, and expressed the hope that this phenomenon might become a reliable diagnostic sign.

Table II and Figs. 4 and 5 demonstrate fairly convincingly that per-stimulatory fatigue appears in patients with varying pathology and is not pathognomonic of any specific group. Nor does it follow recruiting or non-recruiting deafness: it can be found in both groups. Its frequency in the recruiting group (including cases with incomplete recruitment) is 12 per cent and in the non-recruiting group it is 13 per cent.

It may be argued that the width of the threshold tracings would nevertheless be a distinguishing factor in separating recruiting and non-cruiting cases in the per-stimulatory fatigue test. Thus, for instance a small tracing with high fatigability would speak against an acoustic tumour while large tracings would fit well into this category. It must be pointed out, however, on the basis of the earlier (1957) series and on the present data that large tracings do appear frequently in recruiting deafness, especially at the low and middle frequencies, and that they cannot be taken as a sign of non-recruiting deafness.

As far as cases with acoustic tumours go, I do not believe that any single audiometric test should be relied upon exclusively. Hearing loss with absent loudness recruitment is generally seen, possibly accompanied with per-stimulatory fatigue. However, tests for vestibular function are positive in nearly all instances, there are early signs of Vth nerve paresthesias and almost always the cerebrospinal fluid protein is increased beyond 50 mg per cent. By piecing together the results of the clinical examination, the clinician is led much more safely to a reliable diagnosis than by concluding the presence of a tumour for a few hearing tests alone.

Per-stimulatory fatigue can appear in pure end-organ disease, and it appears in nerve fibre deafness and also in cortico-central lesions. Its presence is only one sign of a particular response of the ear, and the clinician must fit it into the picture he has obtained from other oto-neurological tests and interpret the findings accordingly.

From the technical point of view great care is necessary in per-stimulatory adaptation tests to ensure that the response really comes from the ear in question. Masking must be applied according to the same principles as in ordinary audiometry; the results with an unmasked good opposite ear often leads to bizarre tracings, which may be entirely misleading.

Similarly as direct recruitment tests, per-stimulatory fatigue tests add to the otologist's knowledge of the functional characteristics of the ear. An ear with high fatigability would apparently benefit very little by a hearing aid, and the ear might easily become further depressed in prolonged exposure to noise.

Summary

Results of direct loudness balance tests, and of per-stimulatory fatigue tests, are reported in a series of 98 unilateral cases of perceptive deafness. It is concluded that the presence or absence of recruitment must be fitted with the general results of the oto-neurological examination, and loudness balance tests alone should not be used for localizing the lesion to the end-organ or retrocochlearly. The clinical evidence in many disease groups favours this interpretation, but there are enough cases with contradictory results to deny the recruitment phenomenon the pathognomonic rôle of always indicating end-organ disease.

Per-stimulatory fatigue also appears in various clinical groups: while it adds to the knowledge of the ear's functional capacity it cannot be given pathognomonic diagnostic importance.

In general, it is emphasized that the audiological tests should be interpreted as a part of the oto-neurological examination, and conclusions regarding the etiology of the disease should only be drawn on basis of a thorough clinical examination.

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OBSERVATIONS ON PETROSAL AND VIDIAN NEURECTOMY IN CHRONIC VASOMOTOR RHINITIS

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UNTIL recently the literature has generally conveyed the impression that chronic vasomotor rhinitis is allergic in origin, relieved by antihistamines and cured by specific desensitization. General experience, however, has contradicted this and several authorities now suggest that this common and distressing disorder is in fact primarily an expression of autonomic imbalance (Walsh, 1960; Malcomson, 1959; Wilson, 1960).

In 1943, Fowler, reporting an unusual but significant unilateral vasomotor rhinitis following ipsilateral stellate ganglionectomy suggested that experimental surgery might uncover the fundamental mechanism of vasomotor rhinitis. It now seems reasonable to believe that this hope has been realized.

Clinical Features

These are all too familiar to require elaboration, but are briefly recounted to avoid the confusion often engendered by terminology.

The patient complains of constant or continually recurring "colds" or "hay fever". Profuse watery nasal discharge is either perpetual or occurs in frequent attacks that last minutes or hours. Often these attacks are preceded by a feeling of irritation in the nose followed by a prolonged bout of sneezing, lacrimation and a streaming nose.

Characteristically, these attacks occur soon after waking, when they are possibly precipitated by changes of body temperature, induced by getting up, or placing the feet on a cold floor. At other times, they are induced by dust inhalation or purely by emotional stress. Symptoms are sometimes explosive in character, and it has been suggested that this is analogous to an autonomic "epileptiform" attack (Reading and Malcomson, 1954).

As is generally known, there is a clinical variant in which nasal obstruction, chiefly induced by the swollen inferior turbinate mucosa is the chief symptom, sneezing and rhinorrhœa being minimal. These cases, with nasal obstruction characteristically intermittent, worse at night and alternating as to side, are not included in this communication.

The type of chronic vasomotor rhinitis here considered is apparently that designated by Reading and Malcomson (1954) as non-specific

paroxysmal sneezing and rhinorrhœa, or by Harper (1959) as non-specific allergic rhinitis. Such symptoms often occur in stable personalities, but they are frequently initiated by some experience arousing emotional tension and subsequently are aggravated by emotional stress or occur in the period of relaxation that follows previous mental effort or emotional effort or strain (O'Neill and Malcomson, 1954).

The nasal mucosa may appear normal, but is often pallid, soggy and swollen. Eosinophilia is frequently shown in nasal smears. Whilst it is agreed that similar changes may result from true antigen-antibody reaction they should not be regarded as necessarily due to allergy.

Those who have accepted an allergic basis for this condition are embarrassed by the difficulty in finding the allergen responsible. In general, the responses to skin sensitivity tests are either negative or non-specific in character. Sometimes a wide variety of positive reactions are obtained, but their very diversity, and the history, proclaim their unreliability. It is no easier to incriminate bacterial proteins, for cultures from the sinus mucosa are often sterile even when the fallacies attending delay in culturing such swabs are excluded. It is the general experience that clinical response to anti-allergic measures are disappointing.

To meet this difficulty, some have extended the use of the term "allergy" to embrace a variety of hyper-reactions, irrespective of antigen and antibody. It may reasonably be objected that such devices imperil verbal precision and do not serve to clarify concepts.

As will later be shown, these tissue reactions in the nose do not necessarily indicate protein hyper-sensitivity nor the liberation of histamine. They can be produced by autonomic imbalance and parasympathetic over-activity, probably by release of acetyl-choline.

A Working Hypothesis

The writer's interest was first aroused by the changes observed in the nasal mucosa following cervical sympathectomy; turgescence and hyperæmia being common, eosinophilia not infrequent. Although unusual, Fowler's case (1943), seemed highly significant. Here a left stellate ganglionectomy had successfully relieved a median nerve causalgia in a woman of thirty-four. Thereafter, the left side of the nose became stuffy and with the advent of the cold season appeared sneezing in spells lasting thirty minutes and profuse watery left sided nasal secretion. Although there was no evidence of allergy the nasal mucosa of the left (sympathectomized) side became pallid, violacious and soggy; smears yielded many eosinophils; the unoperated right side remaining normal in appearance and without eosinophilia.

It will be apparent that all the features of chronic vasomotor rhinitis as considered here can be explained by a simple secreto-motor over-activity in the nasal mucosa. From the standpoint of neurophysiology

it seemed reasonable to assume that this was due to parasympathetic over-activity, no matter how this might be induced.

The peripheral vascular changes induced by emotional states are familiar to all. Thus blushing may be induced by shame or embarrassment, and blanching by fear.

The importance of emotional stress, both in initiating and perpetuating vasomotor rhinitis is in agreement with the observations of Wolff (1950) that an emotional stimulus causes autonomic effects in specific parts of the body. Thus Wolff speaks of "stomach reactors", "pulse reactors", and "nose reactors". It can hardly be doubted that changes in autonomic reaction occur in emotional tension and find their expression in characteristic autonomic patterns. How frequently this is nasal can be observed by the coughing and nose blowing exhibited by any theatre audience after an emotional scene. Gellhorn (1957) suggests that segmental autonomic reflexes increase the activity of a given organ, specifically that it reacts to hypothalamic (emotional) discharges more than do other parts of the body.

Significantly, Wolff has recorded changes in the nasal mucosa during psychiatric interview of a patient with "chronic rhinitis". At mental ease, turbinate biopsy revealed normal mucosal structure and moderate round cell infiltration. A further biopsy taken when the patient was frustrated and on the verge of tears, showed the mucous glands full of secretion, the blood and lymph channels dilated. Marked eosinophilia also occurred, not only locally but also in the blood.

It seemed reasonable to consider resection of the nasal parasympathetic supply in severe and otherwise resistant cases of chronic vasomoter rhinitis, for from previous neurosurgical exerience the writer was aware that petrosal neurectomy had no adverse nasal effects.

Parasympathetic Nasal Pathways

It is now generally accepted that the greater superficial petrosal nerve carries the preganglionic secreto-motor fibres to the nose.

These fibres arise in the superior salivatory nucleus, part of the general visceral efferent column of the mid-brain and emerge in the nervous intermedius at the lower border of the pons, thereafter running with the facial nerve to the geniculate ganglion. Leaving this ganglion the fibres run through a short canal in the petrous temporal, here receiving a twig from the tympanic plexus. They emerge through a hiatus on the antero-superior surface of the petrous and then run forward under the dura towards foramen lacerum, uniting with the deep petrosal (sympathetic) nerve from the internal carotid plexus. At this junction a small parasympathetic ganglion exists (Chorobski and Penfield, 1932).

These conjoined parasympathetic and sympathetic fibres form the Vidian nerve which runs forward through the pterygoid canal to enter

the pterygo-palatine fossa joining the sphenopalatine ganglion lying medially and slightly below the maxillary nerve which supplies its sensory somatic roots. Here the parasympathetic fibres relay and are later distributed to the nasal mucosa with the branches that enter through the sphenopalatine foramen.

The lacrimal fibres are presumed to follow the same course to the sphenopalatine ganglion and post-ganglionic fibres then communicate with the maxillary nerve and enter its zygomatic branch, reaching the lacrimal gland either through the zygomatico-temporal offshoot, running along the lateral wall of the orbit, or they reach the gland through a fine communication to the lacrimal nerve.

Central Autonomic Control

The early concept of Hughlings Jackson (1874) that the autonomic system is represented at all levels of the central nervous system including the cortical is now generally accepted.

The key rôle of the hypothalamus both as the reflex and integrative centre of the autonomic system is established. As yet there is no reliable localization of sympathetic and parasympathetic functions to particular nuclei, nor can these nuclei be linked to specific organs.

It is commonly held that the pre-optic, supra-optic and anterior hypothalamic nuclei are concerned with parasympathetic activities; the paraventricular and posterior hypothalamic nuclei with sympathetic activities.

Much has been written, but as yet little is substantiated, of the functions of the maze of pathways between frontal and other cortical areas, thalamus, hippocampus and hypothalamus (Miller, 1942; Gellhorn, 1943). It is, however, generally recognized that there is both motor and sensory autonomic representation in the cerebral cortex, overlapping and closely integrated with somatic and other cortical areas (Mitchell 1953). This explains both the common association of somatic and visceral effects and the undoubted correlation between somatic, autonomic and mental states.

Petrosal Neurectomy

Section of the greater superficial petrosal nerve for chronic vasomotor rhinitis seems first suggested by Ziegelman (1934) and performed by Murray Falconer at request of Reading and Malcomson (1954), though the writer only became aware of this after his own operations had been carried out.

The operation, under general or local anæsthesia, is performed with the patient sitting up. Through a vertical incision above the zygoma, one inch in front of the external auditory meatus, the temporal muscle is

split and the squama bared. A preliminary burr hole is suitably enlarged, the opening being carried down to the floor of the middle fossa. The dura is stripped up from the floor and held by a lighted retractor. The dura is firmly attached at the foramen spinosum. This foramen is plugged and the emerging middle meningeal artery coagulated and cut. Thereafter the dura usually strips with ease, revealing the mandibular root entering the foramen ovale, slightly anterior and medial to foramen spinosum. The dura is now stripped gently from the antero-medial face of the petrous. This reveals the greater superficial petrosal nerve as a thin shining strand emerging from the hiatus fallopii and running forwards deep to the mandibular nerve. It is important to identify the nerve before its overlying dura is stripped up lest traction injury be caused. Without traction being made upon it, the nerve is cut as it leaves the hiatus fallopii and again as far anteriorly as can be reached, the intervening portion being removed.

Case I. M.L. School-girl (*13 years*). This was the first severe resistant case of chronic vasomotor rhinitis seen by the writer after the hypothesis outlined above was formulated. The patient, then eleven, was first seen in 1954. She was pale, thin and miserable and had been a complete nasal invalid for as long as her parents could recall. Her nose, habitually obstructed, gave a watery discharge, soaking six men's handkerchiefs a day and she was prone to exhausting paroxysms of sneezing. The nasal mucosa was pale, swollen and sodden. Various forms of treatment by different rhinologists had been given without effect over the previous three years. Full investigations of allergy conducted elsewhere were negative, and courses of non-specific desensitization had proved ineffective. Petrosal neurectomy was considered, but believing this entirely untried the experiment was deemed unjustified without further conservative measures.

Two years passed in constant observation of this girl, but her condition remained unchanged, though every form of conservative therapy was tried. The only improvement was a temporary reduction in the number of men's handkerchiefs from six to three a day! Nasal smears were examined on twelve occasions throughout this period, and on nine of these a marked eosinophilia was observed. In 1956 the parents readily agreed even to experimental surgery, and in May 1956 right petrosal neurectomy was performed. The result was dramatic. Within two days the nasal mucosa on the right side had become red, glazed and dry. This shrinkage gave a free airway on the right side. Conditions on the left side at first remained unchanged, but this picture soon altered. On the operated side the colour of the nasal mucosa faded to a normal pink and simultaneously the other side improved. Within three weeks both sides appeared virtually normal and dry. As expected, there was an absence of lacrimation in

the right eye, but unfortunately the operation was complicated by immediate facial paralysis. Over the ensuing months, the girl herself and her parents were so delighted with the change in the nose that they readily forgave the facial paralysis which gradually improved.

Four years later the nasal mucosa appears normal on the right side, though it is slightly pale, swollen and moist on the left. Nasal breathing is free. There is neither sneezing nor discharge. The course of an acute coryza seems unaffected. Slight facial asymmetry has resulted from the facial paralysis. At intervals, nasal smears have been taken from both sides of the nose, again on twelve occasions. No eosinophils have been observed on the right side since operation, but some have been present on the left side on five occasions, though their number is greatly reduced from that seen before operation.

Comment. Though the result was here marred by facial paralysis the response to petrosal neurectomy was immediate and has so far proved lasting. The bilateral effect observed was wholly unexpected. This will be discussed later. Marked improvement in this girl's general well-being was rapid.

Case II. S.J. Male (28 years) Draughtsman. This man had complained of some nasal obstruction, and particularly sneezing and rhinorrhœa, summer and winter alike for ten years. Often when bending forward his nose would "run like a tap" and this seriously affected his work. Two years earlier he had lost his job on this account. After that his symptoms were almost continuous. Various conservative regimes including antihistamines, ephedrine in substantial dosage etc., had proved ineffective. The nasal mucosa was pale, bluish in colour, swollen and œdematous. The nose was filled with watery secretion showing pronounced eosinophilia on smear examination. Bacteriological swabs proved negative on culture. Skin sensitivity tests (Bencard) were negative.

Right petrosal neurectomy was performed September 1956 under local anæsthetic. The exposed greater superficial petrosal nerve before section was subjected to light faradic stimulation. This induced marked sneezing, facial contractions and pain in the ear. Recovery was uneventful. Within three days the right side of the nose was dry, the turbinates shrunken, appearing dull red and glazed. Thereafter there was fairly rapid return to apparently normal state. Nasal smears showed no more eosinophils. Meanwhile the left side of the nose remained just as before, providing an impressive contrast until left petrosal neurectomy was carried out two months later. This had the same result. Lacrimation was lost but this had no adverse effect.

Following his emigration to Canada late in 1959 contact was lost. In the three years under observation he remained entirely free of symptoms.

Case III. J.K. Male (31 years) Bank Clerk. For six years had suffered almost continual watery nasal discharge and frequent sneezing. The nasal mucosa was œdematous but not notably pale. Earlier skin tests (Bencard) had shown marked reaction to a wide variety of inhalants, to mixed moulds and several common foods. Anti-allergic measures had proved ineffective, as had ephedrine.

Petrosal neurectomy (October 1956) gave the same unilateral response as in the previous case, and was repeated on the opposite side in January 1957. He remained entirely free of symptoms whilst under observation for two years. Recently he wrote saying he had no trouble since the second petrosal neurectomy was completed.

Comment. In none of these three patients was any crusting in the nose observed. The same dramatic change in the nasal mucosa with return to apparent normality, and complete relief of symptoms, occurred.

Trans-antral Vidian Neurectomy

In 1957, Malcomson, in a personal communication stated that he had found the Vidian nerve predominantly parasympathetic in effect. He had essayed Vidian neurectomy in a few cases of chronic vasomotor rhinitis with some success.

His approach, necessarily rather blind, was by submucous resection of the septum. Thereafter the mucosa of the nasopharynx was mobilized and its elevation continued forwards on the lateral wall of the nose over the upper part of the medial pterygoid plate. The Vidian fibres in the region of the spheno-palatine foramen were avulsed with elevators.

Impressed by Malcomson's suggestion that Vidian neurectomy might be clinically as effective as petrosal resection, the writer sought to improve the surgical approach. A trans-antral route was deemed preferable and it has proved eminently satisfactory. It will be described briefly, leaving a full account of operative technique to a further communication.

The maxillary antrum is opened as for a Caldwell-Luc and its posterior wall removed. The internal maxillary artery is displayed and secured by extra large Cushing type clips. The artery is preserved in continuity or divided between clips as seems expedient. The maxillary nerve is sought and traced to the foramen rotundum, the essential landmark of the operation. Shortly after leaving foramen rotundum the maxillary nerve gives off branches that travel medially and but slightly downwards to the spheno-palatine ganglion. These nerve bundles are elevated on a nerve hook and the face of the sphenoid laid bare medial to foramen rotundum.

The Vidian nerve passing forwards to the spheno-palatine ganglion is cut and the spheno-palatine fibres are turned aside. This manœuvre, with further dissection if necessary, exposes the anterior funnelled mouth

of the pterygoid (Vidian) canal 10 mm. medial and slightly inferior to foramen rotundum. A guarded flexible probe is inserted into the Vidian canal and diathermy coagulation ensures destruction of the Vidian fibres for a considerable distance.

Illustrative Cases of Vidian Neurectomy

Case IV. C.D. Male (*35 years*) *Seaman.* For 15 years he had suffered excessive watery rhinorrhœa that occasioned much embarrassment. Prone to exhausting bouts of sneezing. Nasal obstruction had never been marked. Nasal mucosa was pale, wet and soggy. No evidence of allergy was found. Over the years, this patient, a seaman, had sought and obtained treatment in practically every port, but had never experienced relief. Bilateral Vidian neurectomy September 1957. This gave prompt and complete relief of former sneezing and rhinorrhœa. The nasal mucosa rapidly assumed a normal pink colour within two weeks. He has remained symptom free since operation.

Case V. V.L. Female (*36 years*) *Laundress.* This patient had a constantly wet and running nose for 15 years. On overage she was soaking 10 men's handkerchiefs a day throughout this period. She was prone to prolonged and severe sneezing. Virtually no relief from ephedrine, antihistamines, cortisone drops, etc. The nasal mucosa was pale-lilac in colour, wet and soggy. Skin sensitivity tests gave positive response to cement dust only. There are several cement works in her vicinity, but her symptoms were unchanged during a long period of residence in a remote country area. Right Vidian neurectomy May 1959. This gave rapid improvement in the appearance of the nasal mucosa on the right side with marked reduction in rhinorrhœa and sneezing. Operation on the left side was postponed so that this patient could be shown at this stage to a clinical meeting of rhinologists in the South-Eastern area. (This meeting was held at Maidstone, May 1959, Case I and three other cases of Vidian neurectomy also being shown). Subsequently left Vidian neurectomy July 1959, produced complete relief of symptoms.

Case VI. D.S. Housewife (*25 years*). A typical chronic vasomotor rhinitis of 5 years' duration. Unrelieved by a variety of conservative measures or changes in environment. Previously subject to asthma, though this had ceased on moving from the Midlands to Kent in 1956. Nasal mucosa pallid, bluish, wet and soggy. Patient soaking 6-10 men's handkerchiefs a day. Right Vidian neurectomy January, 1959, gave immediate relief with characteristic improvement of mucosal appearances on the right side. Three weeks later the left side showed similar improvement.

In May, 1960, the patient returned saying that the right side continued to be clear and dry but the left side of her nose had been stuffy and

prone to excessive watery discharge for the previous 4 months. On examination, the nasal mucosa on the right side was fairly pale but not boggy, on the left was pale, bluish in colour, and boggy. This patient is quite emphatic that the relief given on the right side is such that she now wishes the left side to be operated upon.

Comment. This is one of several cases giving a bilateral result. The improvement on the unoperated side typically occurred after an interval of a few weeks. Characteristically the changes in mucosal response on the unoperated side are less evident, and in this case, as in one other there has been relapse on the unoperated side only. The patient's voluntary return specifically requesting completion of bilateral operation seems convincing testimony.

Case VII. M.B. Schoolboy (11 years). This boy had received attention for the previous 4 years. The nose was almost constantly obstructed and he was allegedly prone to constantly recurring colds. Nasal discharge was characteristically watery but, at times, would become purulent. Sneezing was excessive. Adenoidectomy and antral washouts in 1955 gave no improvement. The nasal mucosa was violaceous, thickened and moist. Small polypi were present. Radiologically the antral mucosa was seen to be grossly thickened. In 1956 small nasal polypi were removed; antral washouts were clear; inferior turbinates were cauterized. These measures gave some relief of nasal obstruction, but vasomotor rhinitis continued. Skin sensitivity tests gave strongly positive results, to house-dust and feathers and also to a variety of foods, inhalants, and moulds (groups A4, A9, A10, A12, and A13 of Bencard's series).

Specific desensitization gave no improvement. Anti-histamines, ephedrine, etc., were similarly ineffective.

Over a period of 4 years a wide variety of therapeutic measures had failed to relieve either sneezing or constantly recurring discharge. Progressive hyperplastic changes in the inferior turbinates produced increasing obstruction. Bilateral transantral Vidian neurectomy, November, 1959. The antral mucosa was grossly thickened and fibrous and infiltrated by leucocytes, plasma cells and eosinophils. Bacteriological swabs immediately plated on to culture media proved sterile.

Result. In the immediate post-operative period, the nose became dry and sneezing ceased. Over the next month, the nasal airways gradually improved but some obstruction persisted from the hypertrophied fringes of the turbinate mucosa. This has been relieved by surgical trimming of the excessive turbinate fringes.

Comment. A typical case of so-called allergic rhinitis but with complete failure of anti-allergic measures. Vidian neurectomy has given immediate relief maintained until the time of writing. In this case, operation was

undertaken with considerable misgiving, as the small space available seemed likely to magnify technical difficulties. In fact, the relative shallowness of the pterygo-palatine fossa more than compensated for the minimal exposure available and no difficulty was experienced.

Case VIII. M.D. Housewife (31 years). Referred by Mr. J. B. Blacklay (Folkestone). Had suffered persistent watery rhinorrhœa and nasal obstruction together with severe bouts of sneezing for 9 years. Symptoms were fairly constant throughout the year, unaffected by climatic or other environmental changes. Over the years, despite much varied treatment by three rhinologists and a psychiatrist, there was no alleviation and the condition had steadily deteriorated. For many months past, she had soaked 20 men's handkerchiefs a day. Nasal mucosa showed no significant changes except for some pallor. She stated that the nasal dripping could be unilateral or bilateral and intermittent obstruction occurred but this did not stop the dripping nose.

Enquiry revealed that the symptoms arose with marriage which the patient freely admitted had been unsatisfactory from the outset. Marital relationships steadily deteriorated and the symptoms grew worse. The patient claimed that she now could not tolerate her husband and would have separated but for the birth of her child 6 months previously. Sexual relations had ceased, the patient commenting that this worried only her husband.

In this case, vasomotor rhinitis seemed entirely due to emotional factors. Whilst the dripping nose seemed to serve as a husband repellent, the patient claimed she was anxious to be cured as it was an intolerable nuisance when she was dealing with her baby to whom she was clearly devoted. Operation: right transantral Vidian neurectomy December, 1959 (in presence of Mr. Blacklay). As great technical difficulty was experienced, chiefly from the heavy bone structure, only the right side was then operated upon. This gave immediate improvement on the operated side which became clear and dry, though the left side of the nose was dripping as before, the same being true of lacrimation. Left Vidian neurectomy was then carried out in March, 1960, and gave complete relief on the left side.

Comment. Complete symptomatic relief and a highly gratified patient. Though recent, this result, to judge from previous cases, should endure. This case is included here, as the emotional factors were so marked. That unintentional psychotherapy is not responsible for the result is shown by the persistence of unilateral symptoms, as previously, in the interval of the 4 months between operations on the right and left sides.

Of the four failures, three occurred in the first twelve cases, possibly due to technical faults resulting in incomplete Vidian section. Of the last twenty-eight cases, twenty-seven were entirely successful. One has

experienced no relief whatever, similarly lacrimation is unimpaired, though at operation one had no doubt as to the technical efficacy of nerve section.

Overall Results

	Cases	*Complete relief, Rhinorrhœa and Sneezing*
Petrosal Neurectomy	3	3
Vidian Neurectomy	40	36

In the forty cases subjected to Vidian neurectomy, bilateral operation has been completed in one session in twenty-two. In eighteen other cases operation on the second side has been deferred, either through technical difficulty or merely through desire to assess operative result. In this event an interval of at least four weeks has been allowed. During this period, five patients have shown improvement on the unoperated side, generally occurring in the third week after initial operation, and this has provided complete relief. On one occasion, the bilateral response appeared almost immediately. The changes in nasal mucosa, never as marked with Vidian as with petrosal neurectomy, have been much less apparent on the unoperated side even though satisfactory bilateral symptomatic response has been observed.

Of the five patients with bilateral result (28 per cent), two, operated on more than eighteen months ago, have returned requesting operation on the second side. Both have stated (as in Case VI) that the improvement on the unoperated side lasted about a year, then relapsed to the previous state. In both, the operated side has maintained the former relief.

The significance of this bilateral result will be considered later.

Lacrimation

Schirmer's tests is now routinely carried out, both pre- and post-operatively and at follow-up examinations, but in many of the earlier cases this unfortunately was not done.

It will be appreciated that Schirmer's test is quantitatively inaccurate and provides only a relative guide to lacrimal secretion. Indeed we lack any satisfactory clinical test of lacrimal function (Rycroft 1960).

In most cases there has been immediate and marked diminution of tear secretion. The conjunctiva however is never wholly dry, apparently being nourished by the accessory lacrimal glands, or goblet cells of the conjunctiva. This circumstance protects the patient from the feeling of irritation and the surface corneal changes (kerato-conjunctivitis sicca)

that attend the dry eye induced by Sjögren syndrome or post-irradiation injury.

Where normal lacrimation has been abolished from Vidian neurectomy, no return of lacrimation has yet been noted. Several cases with sustained clinical relief of nasal symptoms have shown little apparent abnormality of lacrimation three to six months after operation, but in the absence of previous record this cannot with certainty be attributed to regeneration.

It is regretted that these observations lack precision. As will be apparent, the apparently sustained lacrimal function may be due to:

(1) The lack of satisfactory tests of lacrimal function;

(2) Regeneration of lacrimal secreto-motor fibres (Gardner *et al.*, 1947);

(3) Possible alternative pre-ganglionic pathways.

In Case I—The right eye was virtually dry following petrosal neurectomy for four years, since when there has been some return of lacrimation induced particularly by eating. As there is slight weakness of the lower lid resulting from earlier facial paralysis, there is now some crocodile tearing.

More attention is now being devoted to this problem which will form the basis of another contribution elsewhere.

Complications

In this series there has been no death, nor complication, other than those renumerated here.

One petrosal neurectomy (Case I) was attended by a facial paralysis which has largely recovered but with synkinesia and asymmetry of smile. This, admittedly a severe complication, is a known risk of petrosal neurectomy, though in most cases recovery of resultant paralysis is both more rapid and complete. It is generally assumed to result from traction on the greater superficial petrosal nerve resulting in trauma to the geniculate ganglion area.

Its incidence is difficult to assess. It has occurred but once in this series of five petrosal neurectomies (in three patients) and a few others performed for other indication in previous neurosurgical experience. Gardner *et al.* (1947) recalled 31 petrosal neurectomies with 7 facial palsies, generally starting fourth post-operative day and clearing in two months. From inadvertent damage to petrosal area in trigeminal root section, it is a well-known sequel, generally immediate in onset, and clearing more or less completely after some months. In Case I of this series its severity, at least, is attributed to injudicious use of diathermy coagulation too near the point of emergence of the petrosal nerve into the middle fossa.

The few complications of Vidian nerve section seem directly attributable to the writer's technical inadequacy. One such operation has been

followed by slight diplopia on extreme upward gaze and this has persisted. Fortunately its degree is slight and induced only on such extreme of vertical ocular movement that it occasions the patient no significant disability. In that operation, the writer became lost in the upper part of the pterygo-palatine fossa close to the inferior orbital fissue. An ophthalmologist (Mr. J. Ormrod) believes the diplopia due to slight scarring directly hindering the inferior rectus muscle.

In another case the writer, unable to expose the Vidian nerve or canal satisfactorily, deliberately removed the spheno-palatine ganglion. This has resulted in ipsilateral analgesia of the hard palate but is no disability. This hardly calls for comment but the inclusion of somatic sensory fibres in the resection hardly lives up to the ideal that "each operation should be a superb physiological experiment".

The sole other complication has been slight hyperæsthesia of the central area of the hard palate in one patient, that initially produced discomfort when the habitual denture was worn. This is attributed to slight inadvertent injury to somatic fibres from the spheno-palatine ganglion.

Bilateral Response to Unilateral Operation

As previously mentioned this has been observed once in three petrosal neurectomies, and in five of eighteen Vidian neurectomies. Characteristically, it appears after an interval of two to four weeks, the mucosal changes being slower in evolution and less marked in degree. Also, as previously mentioned, it may be maintained (four years to date) or relapse after a year or so.

Clearly such response cannot logically be attributed to unilateral section of efferent secreto-motor fibres, and we are forced to find an alternative explanation.

The existence of autonomic afferent fibres, often disputed, is now generally accepted (Mitchell 1953). Although Christensens' investigations (1934) in cats led him to conclude that the spheno-palatine ganglion cells are essentially efferent, undoubted afferent fibres exist in the greater superficial petrosal nerve (Chorobski and Penfield, 1932). The existence of afferent fibres in the Vidian nerve at least in the cat is clear from Malcomson's experiments (1959). Here it was found that faradic stimulation of the Vidian nerve alone repeatedly led to violent sneezing. This can occur with similar stimulation of the greater superficial petrosal nerve in man (see Case II). Malcomson moreover found that after Vidian section, similar stimulation of both the peripheral and the central ends of the Vidian nerve provoked the same sneezing response. Slome (1960) witnessing these experiments, is left in no doubt of the existence of autonomic afferents in the Vidian nerve.

From common clinical experience we know that in many patients

with vasomotor rhinitis a sharp attack of rhinorrhœa and sneezing is evoked by non-specific nasal stimuli, such as exposure to various dusts, etc. If it is assumed that the afferent side of this apparent reflex can be over autonomic rather than purely somatic sensory pathways, a satisfactory explanation of these clinical responses can be found.

Unilateral petrosal or Vidian section will sever the ipsilateral efferent autonomic supply and reduce by half the afferent supply. It is an accepted postulate of neurophysiology that before afferent impulses excite an effector reflex they must reach a certain threshold value. It is also accepted that this characteristic of somatic response applies equally to the central autonomic system.

From this it is fair to postulate that the bilateral clinical response may be due to the reduction of afferent autonomic stimuli to below an adequate threshold value. Clearly their failure at times to endure may be due to gradual reduction in this threshold.

One may speculate further that two types of vasomotor rhinitis exist—one primarily induced purely by central stimuli, emotional or other, inducing para-sympathetic overactivity—the other, largely triggered by nasal stimuli producing the same effect by autonomic reflex.

Although this subsidiary hypothesis accounts satisfactorily for the clinical observations described, it must perforce remain, for the present, a pure hypothesis.

Petrosal and Vidian Neurectomy Compared

Both operations have been remarkably successful in providing immediate and sustained relief of symptoms.

Petrosal neurectomy, a purely parasympathetic resection has, in each of the three cases observed, given startlingly abrupt changes in the nasal mucosa. The rapid change of a pale, wet and œdematous mucosa to a dry, glazed, red and shrunken appearance is shortly followed by resumption of apparent normality.

Vidian neurectomy necessarily divides some sympathetic fibres and, by the writer's technique, also involves ligation of the internal maxillary artery. Experience of this arterial ligation alone in other conditions, has not revealed demonstrable change in the nasal mucosa. Here it may tend to neutralize the vasodilator effects of sympathetic section. Vidian neurectomy has in no case given the florid mucosal changes that follow petrosal section. There is however a gradual improvement of the nasal mucosa which often appears normal within two months or so. In a few, some pallor and slight bogginess tend to persist. The patients however comment on improvement in their nasal airway and are entirely relieved of former sneezing and rhinorrhœa. Their gratitude is marked.

Neither operation has been attended by crusting in the nose and reaction to acute coryza seems unchanged. Even where emotional factors

have seemed particularly important, no substitution of symptoms has followed the relief of vasomotor rhinitis.

Neither operative technique is simple, but trans-antral Vidian neurectomy generally takes no longer to perform. Ordinarily, both sides can be completed, if desired, in an hour. The patient suffers little inconvenience and is fit for discharge in a week. From fear of facial palsy and possible risk of extra-dural hæmatoma, the writer would hesitate to consider bilateral petrosal neurectomy in one session.

Summary and Conclusions

The allergic theory of chronic vasomotor rhinitis is unsatisfactory. It has been notoriously difficult to identify the allergen concerned, and response to anti-allergic measures is disappointing to say the least.

It is shown that the mucosal appearances of allergy and the eosinophilia can be induced purely by autonomic effects and relieved by parasympathetic section.

The hypothesis is advanced that all the phenomena of chronic vasomotor rhinitis are mediated purely by parasympathetic over-activity—no matter how this may be induced.

Clinical experience of 43 extremely severe and otherwise resistant cases treated by petrosal or Vidian neurectomy is presented. These operations have almost uniformly given dramatic relief. Illustrative cases are presented. Whilst it is too early to assess relapse rate, if any, no case of recurrence has yet been seen on the side of parasympathetic resection in a follow-up extending to a maximum of four years.

An unexpected bilateral response to unilateral petrosal or Vidian section is described and an explanation found.

The operative methods of petrosal and Vidian neurectomy employed are briefly described and their respective merits discussed.

Acknowledgements

My thanks are due particularly to Mr. R. B. Blacklay, F.R.C.S., and others who have kindly referred their patients to me. Also to Professor D. Slome (Royal College of Surgeons) for his interest and helpful advice.

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BLOODLESS OPERATING FIELD IN MIDDLE-EAR SURGERY

REVIEW OF 138 CASES OF INDUCED HYPOTENSION WITH HEXAMETHONIUM BROMIDE (C_6)

By F. HOLMES (Edinburgh)

In exploratory and reconstructive surgery of the middle ear, performed under general anæsthesia, the achievement of a bloodless operating field by means of induced hypotension may present greater difficulties than in other branches of surgery. Several factors may account for this, the most important being the tendency for blood to accumulate in the middle-ear cavity and the frequent presence of chronic or sub-acute infection and hyperæmia. The structures at the site of operation are small and, therefore, readily obscured by a relatively small quantity of blood. This type of intervention is commonly performed on healthy adolescents or young adults and such patients are considered to be particularly resistant to ganglionic blockade. However, no convincing evidence has been advanced to suggest that such a resistance can develop. On the contrary, Zaimis (1955, 1956) has shown that additional doses of ganglion-blocking agents always increase and prolong blockade and she postulates that the apparent tolerance is due to these substances inducing a sensitization of the peripheral vascular system to adrenaline and noradrenaline.

Surgery of the middle ear is not thought to require deep general anæsthesia and this may be so light that surgical stimuli produce fluctuations of blood pressure and pulse rate. This is particularly likely to occur in young patients. A similar observation was made during earlier experiences with hexamethonium bromide (Holmes, 1956). Whether such fluctuations are due to the mechanism suggested by Zaimis or to an increase in circulating adrenaline resulting from inadequate anæsthesia, they can occur in the presence of full ganglionic blockade and they may be modified or prevented by deep general anæsthesia.

The 138 operations reviewed (occasionally two operations were carried out on one patient) have been divided into three groups according to the anæsthetic technique used. The subjects were in no way selected and a particular combination of agents was employed exclusively for a period. The first group of 49 was performed under thiopentone, a relaxant, nitrous oxide and oxygen, trichloroethylene and pethidine. In the second

group of 39 operations hydroxydione (Presuren), nitrous oxide, oxygen and trichloroethylene were used while in the third group of 50, hydroxydione, nitrous oxide and oxygen and halothane were given. In each of the 138 cases hypotension was induced with hexamethonium bromide and all the patients were positioned on the operating table in a similar manner (Fig. 1), although the degree of "break" in the lower half of the

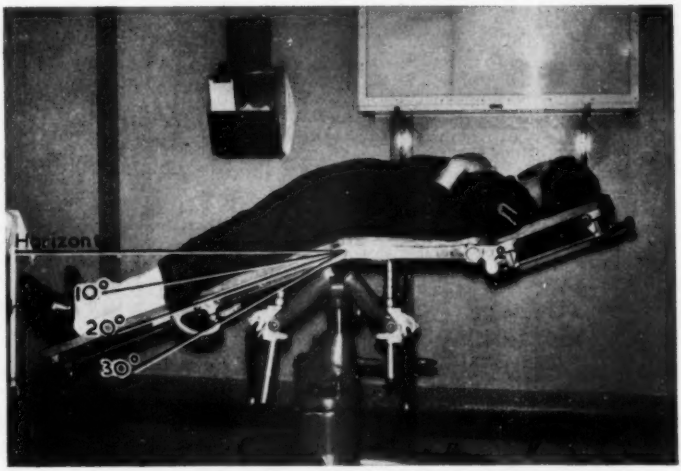

FIG. 1.
Illustrates position of patient on the operating table.

table was sometimes modified according to the patient's circulatory response. Local injections incorporating adrenaline were not used as it was thought that such mixtures would increase blood pressure and pulse rate. The incidence of satisfactory ischæmia and the amounts of hexamethonium bromide required in the three groups of operations are of interest. Assessment of ischæmia was based on the surgeon's opinion but the anæsthetist was able to observe the operative site by means of an observation tube fitted to the operating microscope.

Group I

The 49 operations in this group were carried out under anæsthesia with thiopentone (between 250 and 1,000 mg.), a relaxant (tubocurarine chloride, gallamine or scoline in sufficient doses to prevent reflex response to endotracheal intubation), nitrous oxide (6 litres/min.) and oxygen (3 litres/min.), trichloroethylene and pethidine (between 10 and 150 mg.). Respiration was only controlled when it was impaired following the

administration of pethidine. The quantities of hexamethonium bromide used ranged from 20 to 275 mg., the average dose being 121 mg. Operating time varied from 85 to 300 minutes and the average duration was 160 minutes. Table I indicates the degree of ischæmia achieved and the amounts of C_6 used in the different age groups. It will be noted that of the 45 operations performed on patients aged between 11 and 50 years, satisfactory ischæmic results were obtained in only 19.

TABLE I.

WOUND ISCHÆMIA AND AVERAGE DOSES OF HYPOTENSIVE AGENTS RELATED TO PATIENTS' AGES IN GROUP I.

Age	Number of Operations (49)	Ischæmia of Operating Field			Average Dose of C_6 in mg.	Average Dose of Pethidine in mg.	Average Dose of Thiopentone in mg.
		Good (9)	Adequate (14)	Poor (26)			
<11	1	0	1	0	80	50	350
11-20	15	1	4	10	109	55	520
21-30	8	2	3	3	131	56	512·5
31-40	10	1	3	6	130	82·5	560
41-50	12	2	3	7	144	63·5	525
51-60	3	3	0	0	50	41·5	550

Group II

In the 39 procedures in this group anæsthesia was induced with 5 per cent. hydroxydione in 0·5 per cent. procaine solution (between 500 and 1,500 mg.) and maintained with nitrous oxide (6 litres/min.), oxygen (3 litres/min.) and trichloroethylene. No relaxants were employed in these subjects and respiration was spontaneous in all. The dosage of hexamethonium bromide varied between 20 and 150 mg., the average being 73·5 mg. Operating time was between 70 and 255 minutes and the average duration was 135 minutes. Table II shows the ischæmia achieved and

TABLE II.

WOUND ISCHÆMIA AND AVERAGE DOSES OF HYPOTENSIVE AGENTS RELATED TO PATIENTS' AGES IN GROUP II.

Age	Number of Operations (39)	Ischæmia of Operating Field			Average Dose of C_6 in mg.	Average Dose of Presuren in mg.
		Good (18)	Adequate (9)	Poor (12)		
<11	1	1	0	0	50	500
11-20	12	2	3	7	90	1,000
21-30	5	2	2	1	100	1,000
31-40	9	2	3	4	82	1,143
41-50	6	5	1	0	45	900
51-60	2	2	0	0	40	1,000
61-70	2	2	0	0	25	500
71-80	2	2	0	0	50	625

the amounts of C_6 used in the different age groups. It will be noted that 50 mg. hexamethonium bromide was required in the two operations shown in the last line of the table. These were carried out on a male, aged 75 years, in whom depression of vasomotor activity was more difficult than might be expected at that age. Of the 32 operations performed on patients aged between 11 and 50 years, satisfactory ischæmic results were obtained in 20.

Group III

In the 50 operations in this group the anæsthetic agents were 5 per cent. hydroxydione in 0·5 per cent. procaine solution (between 500 and 1,500 mg.), nitrous oxide (6 litres/min.), oxygen (3 litres/min.) and halothane (5 to 80 ml.). No relaxants were employed and respiration was spontaneous in all cases except two. In these two subjects controlled respiration became necessary for periods of 5 and 8 minutes respectively shortly after the beginning of the administration of halothane. The amounts of hexamethonium given varied between 10 and 150 mg., the average being 51·5 mg. Operating time was between 55 and 185 minutes and the average duration was 100 minutes. Table III indicates the degree of ischæmia obtained and the amounts of C_6 used in the different age groups. Satisfactory operating conditions resulted in 39 of the 41 operations on the subjects aged between 11 and 50 years.

TABLE III.

WOUND ISCHÆMIA AND AVERAGE DOSES OF HYPOTENSIVE AGENTS RELATED TO PATIENTS' AGES IN GROUP III.

Age	Number of Operations (50)	Ischæmia of Operating Field			Average Dose of C_6 in mg.	Average Amount of Halothane in ml.	Average Dose of Presuren in mg.
		Good (37)	Adequate (11)	Poor (2)			
<11	1	0	1	0	35	50	500
11-20	13	7	6	0	64	45	877
21-30	8	6	2	0	50	44	1,000
31-40	8	6	1	1	74	33	1,000
41-50	12	10	1	1	44·5	43	1,000
51-60	7	7	0	0	23·5	18	936
61-70	1	1	0	0	20	20	1,000

Discussion

Induced hypotension and elevation of the operative site can produce varying degrees of wound ischæmia but classification of such effects must necessarily be simplified. To be of practical value, they must be measured by whether or not they achieve their objective, namely to give the surgeon uninterrupted facilities for assessing accurately the nature of pathological changes and carrying out the appropriate reconstructive procedure. In the cases presented here ischæmia was classified as follows:

Good—middle ear bloodless.

Adequate—middle ear sufficiently bloodless to allow uninterrupted exploratory and reconstructive procedures.

Poor—bleeding sufficient to impede operation, even if only periodically.

Not infrequently the view is expressed that "anyway, it was better than it would have been without hypotension". While probably true, it is doubtful whether such a point of view should be accepted. Nothing really worth-while is gained if operating conditions are satisfactory at first, only to deteriorate during the latter, and vital, part of the operation.

It is not practicable to fix an arbitrary blood pressure level below which hypotension is likely to become dangerous because the lowest "safe" level will vary with the physical state of the subject in whom it is induced. Adequate wound ischæmia appears to depend not only on the degree of systolic hypotension but also on a reduction of pulse pressure to less than 15 or 20 mm. Hg and of pulse rate to fewer than 100 beats per minute. Fig. 2 illustrates that bloodless operating conditions are possible in the presence of a relatively high systolic blood pressure as long as the pulse pressure is small and pulse rate below 100 beats per

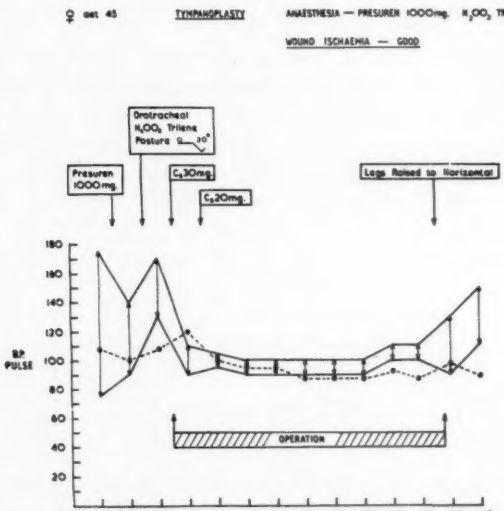

FIG. 2.

Illustrates that a bloodless operating field is possible in the presence of a relatively high systolic blood pressure when pulse pressure is small. Rapid rise of blood pressure after return to horizontal posture suggests that hypotension was, in part, due to impairment of venous return (posture).

minute. On the other hand, Fig. 3 shows that adequate hypotension may not provide satisfactory ischæmia in the presence of tachycardia. The blood pressure level at which a dry operating field is achieved will vary also according to the circulatory state of the subject and the pathological process in the middle ear. Given adequate depth of general anæsthesia and a posture which promotes gravitational blood flow from the operative site, satisfactory operating conditions are likely at a blood

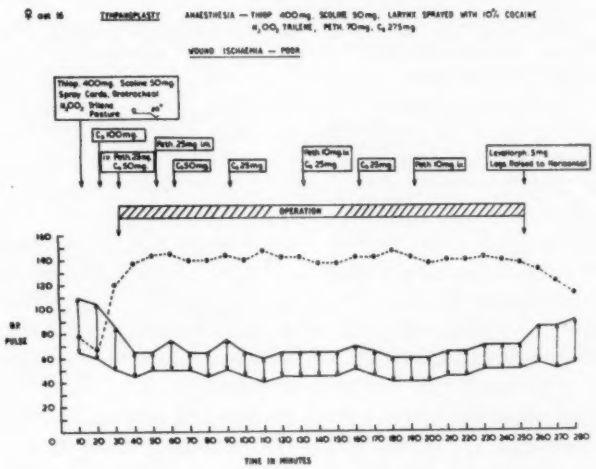

FIG. 3.

Illustrates that wound ischæmia was poor in the presence of tachycardia in spite of adequate hypotension. Considerable quantities of C_8 and pethidine did not improve operating conditions.

pressure level higher than that which would lead to peripheral circulatory failure. As long as capillary circulation is evident in the most elevated part of the body, namely the operative site, adequate blood flow is probable elsewhere. Generally speaking, in the healthy adolescent and young adult a lowering of systolic blood pressure to a level between 50 and 60 mm. Hg was required, while in the more elderly subjects a reduction to between 65 and 75 mm. Hg was usually sufficient.

When comparing wound ischæmia in the three groups and the amounts of hexamethonium bromide required to produce it (Table IV) the method of general anæsthesia appears to have had an important accessory influence on the extent to which ganglionic blockade was capable of providing satisfactory operating conditions. This conclusion appears permissible as other relevant factors, such as operative site and procedure and the patient's posture, were comparable. The differences in average operating

times in the three groups (Table IV) may to some extent reflect variations in operating conditions.

Some factors come to mind which probably contributed towards the unsatisfactory conditions experienced in the first group of patients. The administration of thiopentone, relaxants and pethidine is likely to have impaired spontaneous respiratory efficiency and lead to accumulation of carbon dioxide. A number of patients became apnœic for varying

TABLE IV.

INCIDENCE OF SATISFACTORY WOUND ISCHÆMIA, AVERAGE DOSES OF C_6 AND OPERATING TIMES IN THE THREE GROUPS OF PATIENTS.

Group	Satisfactory Ischæmia	Average Dose of C_6 in mg.	Average Operating Time in mins.
I	In 23 Out of 49	121	160
II	In 27 Out of 39	73·5	135
III	In 48 Out of 50	51·5	100

periods, but aided or controlled respiration did not prevent fluctuations of blood pressure and tachycardia. The administration of levallorphan in three patients was followed by a marked deterioration in operating conditions, although there was little or no increase of blood pressure. In the presence of tachycardia operating conditions were nearly always poor and generally it was not possible to reduce the pulse rate, even by giving liberal doses of pethidine. The impression was gained that in the younger patients in this group general anæsthesia was of insufficient depth to prevent fluctuations of blood pressure and pulse rate resulting from surgical stimulation. This situation was more evident during the latter part of the intervention, although in some subjects it was present throughout.

In all patients under 21 and over 60 years of age premedication included atropine, while in the other age groups scopolamine was employed. Atropine produces an increase in pulse rate but it was thought unlikely that this effect would persist throughout a lengthy operation and frequently tachycardia became even more troublesome during the later stages of the intervention. In any event, this complication was equally common in the patients who had received scopolamine.

In the second group of subjects anæsthesia was induced with hydroxydione. This agent, while causing no marked respiratory depression, is a

more powerful and longer acting basal narcotic than thiopentone and has the additional action of reducing systolic blood pressure to about 100 mm. Hg and lowering the pulse pressure to about 30 mm. Hg in normotensive subjects. This agent also appears to reduce laryngeal irritability and in nearly all cases intubation was found to be easy under hydroxydione alone. Thus the use of relaxants and pethidine and their undesirable effect on spontaneous respiratory efficiency were avoided. Aided or controlled respiration did not become necessary in any patient in Group II. It will be noted that satisfactory operating conditions were obtained in a higher proportion of subjects and that smaller doses of hexamethonium bromide were required than in the first group. However, the proportion of failures was still high in the younger subjects and poor operating conditions were again associated with tachycardia, although fluctuations of blood pressure were less noticeable than in Group I. It was concluded that in spite of the deeper basal narcosis provided by hydroxydione, trichloroethylene did not provide sufficient depth of anæsthesia to depress vasomotor activity in all patients and at all stages of the operation. The chief problem appeared to be finding some means of slowing the pulse rate to below 100 beats per minute and to achieve, if possible, a degree of central depression of vasomotor activity.

During the early clinical trials with halothane bradycardia was noted (Bryce-Smith and O'Brien, 1956; Burns, Mushin, Organe and Robertson, 1957). Johnstone (1956) consistently observed depression of sympathetic activity. Burn, Epstein, Feigan and Paton (1957) noted in the course of a pharmacological investigation into the effects of halothane a marked reduction of cardiac output (70 per cent. of that produced by chloroform). They considered the fall of blood pressure to have been greater than would be accounted for by possible ganglionic blockade and suggested depression of the central vasomotor mechanism as the cause.

In view of these observations it was thought that halothane might be helpful in overcoming the difficulties which have been described. It was decided, therefore, to substitute this agent for trichloroethylene in the third group of patients; in every other respect anæsthetic management was similar to that in Group II.

Table III indicates that in the third group satisfactory operating conditions were obtained in nearly all cases. The pulse rate usually fell to between 80 and 90 beats per minute soon after the administration of halothane was begun. In a few subjects in the lower age groups slowing of the pulse took up to 30 minutes to occur. However, this was not of serious import because the rate had settled before access to the middle-ear cavity had been gained. In the two subjects in whom satisfactory operating conditions were not achieved, tachycardia persisted in spite of continuous administration of about 3 to 3·5 per cent. halothane. It has been claimed that this agent should be capable of providing sufficient

hypotension to give adequate operating conditions without resort to ganglionic blockade. This was tried in a few subjects since completion of the cases under review but wound ischæmia was found inadequate with concentrations up to about 3·5 per cent. It may, however, be possible with higher concentrations and controlled respiration. It should be stressed again that in the writer's experience wound ischæmia of the middle ear is more difficult to obtain than in other surgical fields. Once ganglionic blockade was established it was found that the degree of hypotension could be readily modified by alterations in the concentration of halothane (Fig. 4) and, had this been realized sooner, satisfactory ischæmia might

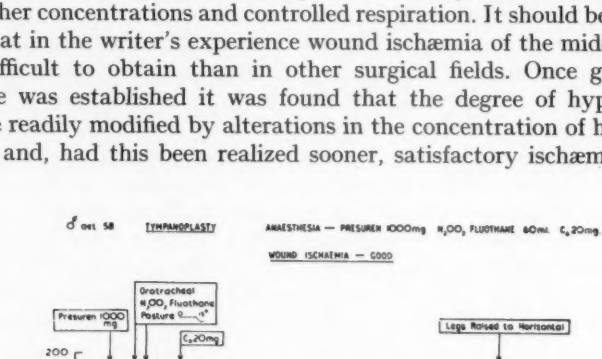

FIG. 4.

Illustrates speedy response of blood pressure and pulse rate to alterations in the concentration of halothane at 50, 70 and 150 minutes.

have been obtained in some of the cases with even smaller quantities of C_6. In two patients in Group III apnœa occurred during the early stages of the administration but adequate spontaneous respiration was quickly re-established by reducing the concentration.

Fig. 1 indicates that the posture of the patients on the operating table ensured that the operative site was the highest point in relation to the rest of the body and thus pooling of blood in the legs was promoted. Furthermore, the considerable "break" in the table must have had the effect of impairing venous return to the heart, thus reducing the cardiac

output; this is likely to have been an important accessory factor in the production of hypotension and the reduction in pulse pressure. The effect on pulse pressure is particularly evident in the case illustrated in Fig. 2 and a similar picture has been observed in a study of postural hypotension of a different nature, when vasomotor activity was unimpaired (Holmes, 1960). It is necessary, therefore, to modify the degree of dependence of the legs according to the subject's circulatory response. A break of 15 to 20° from the horizontal produced no signs of peripheral circulatory failure and in the more resistant patients the angle had to be increased up to 30° before adequate wound ischæmia could be obtained. Tachycardia is a common circulatory response to moderate reduction in venous return and, therefore, the posture employed in these cases may have contributed to the frequent occurrence of this complication. As, however, the gravitation of blood from the site of operation is an essential factor in producing wound ischæmia it was felt that the answer to this problem lay in modifying the tachycardia by central depression. A premonitory sign of dangerous impairment of venous return is slowing of the pulse rate to below 50 beats per minute. This did not occur among the cases presented here, although it had been observed twice in an earlier group in which total sympathetic blockade by high spinal analgesia had been employed. In both cases, some elevation of the legs raised the pulse rate to between 60 and 70 beats per minute.

In the second group, a female aged 38 years, exhibited extreme pallor and apparent stoppage of the heart lasting about 30 to 40 seconds following rapid elevation of the lower half of the table at the end of operation. However, the circulation returned to normal before special measures to ensure this were instituted. This complication was probably due to sudden overloading and dilatation of the right ventricle and, therefore, raising of the legs to the horizontal position must obviously be done gradually.

In no case was return of the blood pressure to normal delayed unduly following the use of hexamethonium bromide. In the majority it did so within an hour or so of the end of operation and in the remainder within four hours. At the end of operation, whenever systolic pressure in the horizontal position was below 80 mm. Hg in young subjects and below 90 mm. Hg in the elderly, 3 to 10 mg. methyl-amphetamine was injected intravenously in order to raise the blood pressure to those respective levels. Insistence on raising the blood pressure rapidly to the pre-operative level is likely to provoke reactionary bleeding and prejudice the result of the operation.

Extensive thrombo-phlebitis of the arm occurred in two patients following the injection of hydroxydione and C_6 through a Mitchell needle. This practice was discontinued and the two agents were, thereafter, administered by different veins. Hydroxydione was injected as rapidly

as possible into the largest available vein and this was followed by elevation and massage of the arm. With this routine no complications were encountered.

Summary

The problems of providing a bloodless operating field for reconstructive procedures on the middle ear are discussed. Discussion is based on a review of 138 cases of induced hypotension with hexamethonium bromide.

The clinical material is divided into three groups of approximately equal numbers, according to the method of general anæsthesia employed.

The choice of anæsthetic agents is shown to have had an important influence on the degree of wound ischæmia obtained. Other important factors in this respect were the age of the subject, the pathological process and the individual response to postural change. Tachycardia appeared to be the most constant factor whenever bleeding was troublesome during operation.

I wish to express my appreciation to Dr. I. Simson Hall and his colleagues for their encouragement and, at times, patience during this investigation.

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SYMPATHECTOMY FOR INNER-EAR VASCULAR INSUFFICIENCY

By T. J. WILMOT (Omagh)

Introduction

In a recent study of 317 cases of perceptive deafness (Wilmot and Seymour, 1960) the diagnostic significance of fluctuation of hearing level and of coincident vertigo was pointed out. Evidence was produced that many such cases are vascular in origin and the indications for treatment were outlined. Sudden perceptive deafness in young people may have a similar ætiology (Wilmot, 1959).

The indications for cervico-dorsal sympathectomy in Ménière's disease were described by Harrison (1956). He was in favour of operation in the bilateral case when the hearing was falling in the better ear in spite of medical measures. He thought that there was a better chance of success if it was done before much hearing loss occurred. Later (1958) he stated "there is a place for sympathectomy in the treatment of Ménière's disease, particularly in bilateral disease in which the hearing is falling off on both sides".

Lewis (1956) stated that sympathectomy may influence the course of Ménière's disease and in certain cases it is a justifiable procedure.

Dix (1956) agreed that sympathectomy is of value in controlling aural vertigo and to a lesser extent the coincident tinnitus. She found, in a small series of cases, that amplified speech interpretation was improved also. The fact that speech discrimination is improved more than pure tone appreciation had been pointed out by Passe (1953) who recognized that this suggested that the disturbance was not confined to the labyrinth and might involve the whole auditory projection pathway. The latter also described the results of treating two series of patients by stellatectomy and by upper dorsal sympathectomy. Vertigo in 60 per cent. and tinnitus in over 20 per cent. were completely relieved in both series, and hearing was substantially improved in 30 per cent. and slightly improved in a further 30 per cent.

We know from the work of Seymour (1960) that there is close correlation between the histological findings in the stria vascularis and the symptomatology of the patient, and earlier (1960) he had further clarified the role of vasodilator drugs in improving labyrinthine vascular flow.

From Seymour's work, it thus seems likely that many purely labyrinthine syndromes are associated with specific small vessel vascular insufficiencies and that other syndromes may occur where such vascular changes may not necessarily be confined to the inner ear. Thus, unilateral vasomotor rhinitis with slight deafness; unilateral gustatory sweating with deafness and tinnitus; the combination of migraine with ocular disturbances and with aural vertigo and the common association of acrocyanosis with inner-ear symptoms in the young female, may all be different manifestations of a common susceptibility.

There has been reluctance on the part of the profession to accept the vascular origin of Ménière's disease, or to believe that perceptive deafness without vertigo can occur from the same cause. If, however, sympathetic block, vasodilator drug therapy and sympathectomy can relieve inner-ear symptoms—whether the disorder be confined to the inner ear or not—the resulting benefit should not be denied the patient on this account.

This reluctance is possibly due to lack of appreciation of two major factors: the first being, that sympathetic block and vasodilator drug therapy are likely to help the patient with aural vertigo only during an acute attack or if the disease is in a very early, fluctuant and reversible stage; the second being, that sympathectomy can, in each individual case, achieve only an amount of recovery proportional to the degree of pre-existing damage to the end organs of hearing and equilibration. It is no more possible to restore a severely damaged labyrinth to normal by sympathectomy than to avoid amputation of a gangrenous foot by the same means (Wilmot 1957). It is for this reason that I have consistently stressed early diagnosis and early treatment.

Here, an attempt has been made to analyse the results of sympathectomy for a small series of inner-ear disorders which had not been helped by other means.

Clinical Material

Out of approximately 500 cases of inner ear disorder without known cause, a mere 29 patients (6 per cent.) have been selected for sympathectomy. The indications for operation have been pointed out earlier (Wilmot and Seymour, 1960) and it is important to stress that sympathectomy is only required in a small percentage of cases.

Of the patients operated on, 23 were male and only 6 female. Tinnitus was present in 27 and fluctuation of hearing in 32 affected ears. Vertigo occurred in 22 cases and in 8 there was complaint of other symptoms, usually a feeling of the head or ear being "stuffed-up" on the affected side. One patient had unilateral facial sweating on the same side as his tinnitus and deafness. All the females showed evidence of poor peripheral circulation, with chilblains and/or acrocyanosis, but this was not a male feature.

All patients showed evidence of hearing loss on the affected side by pure tone audiometry.

With the exception of two males over 50 with diastolic pressures over 100 whose hearing improved with sympathetic block, all patients have been normo-tensive—the average overall blood pressure being 137/84.

In assessing hearing loss we have used pure tone audiometry only. The decibel losses at 250, 500, 1,000, 2,000 and 4,000 c.p.s. have been averaged to give a figure which we have called the Average Hearing Figure (A.H.F.). The A.H.F. has been used to represent the hearing loss of each ear on each occasion tested. Peters' S.P.D.2 audiometers, calibrated at regular intervals against normal hearing young adults and against each other and operated by the same technician under excellent conditions have been used. Audiographs were done by a "quick technique", which has given consistent readings. White noise masking, with or without an insert, has been standard. All audiographs done after sympathetic block or sympathectomy, were done without the technician having access to previous audiographic findings. Our audiographic findings are based on the analysis of 450 audiographs—an average of approximately 6 audiographs before and 6 after operation on each affected ear.

Fig. 1 illustrates the degree of hearing loss, age at time of operation and length of history in relation to the number of sympathectomized ears. It shows that the cases operated on have been predominantly in the 40-50 age group, with symptoms lasting over 2 years and with moderately severe loss of hearing (30-50 decibels).

As part of routine diagnostic procedure, a sympathetic block was done

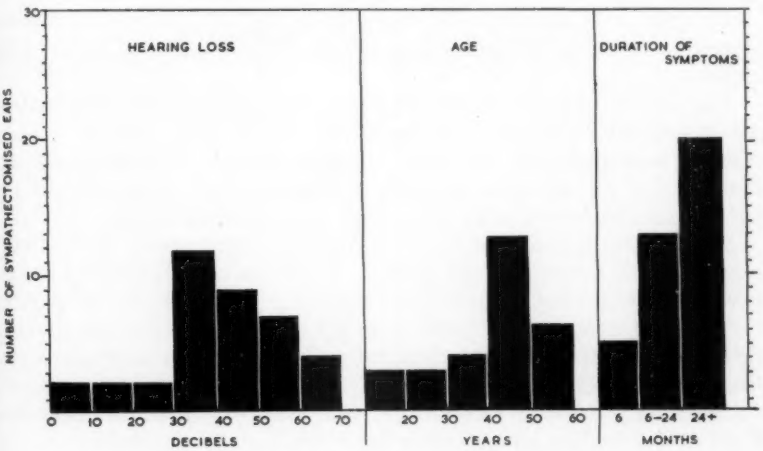

Fig. 1.

for 35 ears at varying intervals before sympathectomy and produced an overall average improvement of 6 decibels in the A.H.F. In one case, there was an average improvement of 42 decibels—in 5 cases there was no improvement, but in only 2 cases did the A.H.F. fall.

With the exception of one patient who emigrated two months after operation, the minimum follow-up period has been 15 months. All, except 5 cases, have been followed-up over 2 years, and the average follow-up period for all cases has been 3 years and 3 months.

In assessing audiographic findings over such periods of time, it should be appreciated that there is a natural tendency in many untreated cases of inner-ear vascular insufficiency for hearing deterioration to occur, and that such deterioration is commoner in cases with coincident vertigo, which in this series was present in 76 per cent. of cases.

Operative Methods

In the first ten patients operated on, a Smithwick pre-ganglionic sympathectomy was done by the upper dorsal approach as a unilateral procedure, the medial portions of the 2nd and 3rd intercostal nerves were excised and the sympathetic trunk divided below the 3rd thoracic ganglion.

The remaining nineteen patients had a simple stellate ganglionectomy, together with the removal of one or more inches of the sympathetic trunk below the ganglion—the vertebral artery was not stripped. In nine of these patients the operation was performed bilaterally.

Results of Operation

1. *Effect upon Hearing.* The majority of our patients were observed for several weeks, and usually much longer, before operation was decided upon.

Fluctuation of the hearing level during this pre-operative observation period was demonstrated audiographically in 32 ears and the *average* swing between high and low A.H.F. readings was 18 decibels in each ear so affected. Following operation, fluctuation was not eliminated but the A.H.F. swing was reduced to an average of 13 decibels in each ear.

In assessing gain or loss in hearing as a result of operation, we have compared the average pre-operative A.H.F. with the average post-operative A.H.F. Any alteration of less than 5 decibels in the A.H.F. as a result of operation we have regarded as insignificant, although it is pertinent to point out that several cases did show slight improvements; also, that a single frequency gain of 20 decibels, producing only a 4 decibels improvement in the A.H.F., may be very obvious on inspection of the actual audiograph and may be of considerable significance to the patient.

A.H.F. gain greater than 5 db. occurred in 17 sympathectomized ears (45 per cent.).

A.H.F. loss greater than 5 db. occurred in 4 sympathectomized ears (10 per cent.).

A.H.F. remained unchanged in 17 sympathectomized ears (45 per cent.).

In those showing improvement, there was an overall average gain of 11·5 db. in the A.H.F. In two ears, the A.H.F. improved by nearly 30 decibels, in 7 ears by over 10 decibels and in 8 ears by between 5 and 10 decibels. In those showing definite loss of hearing, the average A.H.F. fell by 11 decibels.

If we compare the overall average A.H.F. for all 29 patients during the whole pre-operative observation period with the same figure during the longer post-operative observation period we find, instead of a loss of hearing occurring from the natural progression of the condition, that there has been an A.H.F. gain of from 37 to 33 db. i.e. 4 decibels average improvement.

2. *Effect upon Tinnitus.* Pre-operatively, 27 ears were affected—tinnitus being constant in 13 and intermittent in 14.

At the termination of the follow-up period after operation, 3 ears were affected constantly and 7 intermittently. There was occasional, slight tinnitus in 5 and in the remaining 12, tinnitus had disappeared.

3. *Effect upon Vertigo.* Cases of vertigo were divided, by simple clinical questioning, into 3 categories—severe, moderate and slight.

TABLE I

NUMBER OF PATIENTS WITH VERTIGO

	Severe	Moderate	Slight	Total
Pre-operative	7	9	6	22
Post-operative	0	1	8	9

13 patients (46 per cent.) were free of vertigo as the result of operation.

In 6 patients some vertigo returned, usually two or three months after operation. This was in no case as severe as the pre-operative vertigo and was, generally, well controlled by massive doses of Buphenine Hydrochloride (Perdilatal).

All patients have had their caloric reactions recorded by electronystagmography before operation. We have been unable to repeat these

tests on all cases post-operatively but in one patient complete return of function, and in others some improvement in the vestibular function has been demonstrated

4. *Effect upon Other Head Symptoms.* Seven patients complained of a "stuffed-up" feeling and one of gustatory sweating on the affected side of the head pre-operatively. In one case the patient complained after operation of a throbbing sensation in the temporal region on the affected side; in the remaining 6 cases the symptoms were abolished.

These results show that there has been considerable overall improvement in tinnitus and vertigo, and some in hearing and diminished fluctuation.

If we consider all 39 sympathectomized ears we find that; of the 28 with vertigo, 6 (21 per cent.) showed improvement in all the above four symptoms; 15 (54 per cent.) in three out of four symptoms; and 7 (25 per cent.) in two out of four symptoms. Of the 10 without vertigo; only one (10 per cent.) showed improvement in all three symptoms; 5 (50 per cent.) in two out of three symptoms; one (10 per cent.) in one out of three symptoms; and one (10 per cent.) showed no improvement at all.

In those cases with vertigo where all four symptoms improved as a result of operation, there was a significant improvement in the pre-operative A.H.F. level as a result of sympathetic block in 83 per cent. of cases—the average improvement being over 12 decibels. Only two of these patients (33 per cent.) had the type of hearing loss where we were able to confirm the presence of binaural recruitment. The average duration of symptoms in this group before operation was just over a year.

If we compare those cases where two symptoms only improved as a result of operation, there was pre-operative improvement after sympathetic block in 30 per cent. only, and in these cases the A.H.F. improvement was in the region of 5 decibels only. In this group, positive binaural recruitment was demonstrated in 80 per cent. and the average duration of symptoms was nearly three years.

This suggests that response to sympathetic block and duration of history are of some significance in deciding upon operation in patients with vertigo, and that the demonstration of binaural recruitment may be a sign of irreversible damage.

In those without vertigo, however, improvements in the other symptoms were obtained in spite of an average duration of history of over ten years. In this group, hearing losses were such that the binaural recruitment test was inapplicable.

We found, further, that cervical sympathectomy produced, on the average, over twice as much hearing improvement and was much more effective in reducing hearing fluctuation than the upper dorsal operation.

Causes of Failure

Amongst the causes of failure, errors of diagnosis, poor selection of cases and inadequate operation must be considered.

In all cases there was improvement, in at least three out of four symptoms, for a period after operation. In some, relapses occurred a few months—usually three or four—after operation and these cases, for the most part, responded very satisfactorily to vasodilator drug therapy with "Perdilatal"—the latter was used, in most cases, for a period of several months in a dosage of 12 mgms. or more q.i.d.

This suggests that the main trigger mechanism had been abolished by the operation, but some subsidiary sympathetic fibres had survived or regenerated.

In those undergoing cervical sympathectomy, Horner's syndrome persisted throughout the entire follow-up period in all except one patient. It is perhaps significant that this is the only patient whose vertigo appears to be nearly as severe since operation as it was before.

The problem of vertigo persisting after sympathectomy has recently been discussed by Seymour (1960) in his exhaustive study of the ætiology and pathology of Ménière's disease. Obviously, this problem requires further evaluation.

Operative Complications and Sequelae

Copious hæmorrhage, resulting from the slipping of a ligature on the costo-cervical trunk, occurred in one case. It was controlled without damage to the subclavian artery.

In another case the subclavian artery, after it had been retracted downwards with a rubber catheter, went into severe spasm, the radial pulse disappeared and did not return—this patient had no symptoms and no loss of function in the arm.

Small pleural tears occurred in five cases—the resulting pneumothorax absorbed in all cases without incident.

Post-operative pain occurred in a minority of patients. After the upper dorsal approach, intercostal neuralgia was severe in one, moderate in five and insignificant in the remaining four patients. After the cervical operation, pain radiating down the upper arm was severe in two, moderate in eight and insignificant in eighteen. In the latter group, pre- and post-operative shoulder shrugging exercises helped to reduce the incidence and severity of the pain, and the younger patients appeared to suffer less.

One patient, after cervical sympathectomy, and in spite of an excellent result so far as vertigo, tinnitus and hearing were concerned, developed atrophic changes in the hand on the operated side with skin cornification, fissuring, loss of warmth and slight loss of power.

Discussion

Without doubt, the most difficult problem in circulatory inner-ear disorders is to decide on the correct time to operate. If conservative measures are persevered with too long, the optimum time may pass and the operative result be poor—on the other hand, operation, with its possible sequelae, should not be undertaken lightly.

It has already been pointed out that a positive response to sympathetic block and a short history are of good prognostic significance, and that positive binaural recruitment suggests that the affected ear is unlikely to recover fully as a result of operation.

Sex appears to be of significance also. The type of low tone hearing loss which responds best to sympathetic block and sympathectomy is, in my experience, much more common in males. In those under 40 with sudden, and usually irreversible perceptive deafness, however, females preponderate (Wilmot, 1959) but in this group sympathectomy is unlikely to be required. Older females often develop high tone hearing losses which are unsuitable for operation.

The results of cervical sympathectomy in this small series have been generally superior to those of the upper dorsal operation, and increasing experience has tended to reduce operative complications and sequelae. It is possible that further ablation of the sympathetic pathways in the neck may be the answer to those who relapse after stellate ganglionectomy.

Summary

The results of sympathectomy in a small series of cases of inner-ear disorders has confirmed the original findings of Passe and Seymour (1948) that deafness, tinnitus and vertigo are favourably affected.

A favourable response to sympathetic block and a short history improve, while a long history and positive binaural recruitment diminish the likelihood of a good operative result.

I am grateful to Mr. W. F. Smyth of Omagh and Mr. P. H. Golding-Wood of Maidstone who taught me the art of sympathectomy; and to the late J. C. Seymour of the Ferens Institute, Middlesex Hospital, for his constant stimulus and advice. I am indebted to Mr. Duncan Cheyne, my audiology technician, for the constant high standard of his audiography and for the help he has given me in the preparation of this paper.

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CLINICAL RECORDS

A CASE OF ETHMOIDAL OSSIFYING FIBROMA OBSERVED IN A CHILD SEVEN YEARS OLD*

By G. ROSSI and E. CHERUBINI (Turin)

MANY cases of ossifying fibroma are to be found in the otolaryngeal literature of the last 50 years. It is a peculiar kind of tumour, often observed at the level of the facial and cranial bones (Berger; Benjamins; Skolnik and Fornatto; Corbett; Weaver; Agazzi and Belloni; Gignoux and Coll.; Ball; Hara; Smith; Billing and Ringertz; Cooke and Powers; Dechaume and Coll.; Delaire and Kerneis; Fernandez del Moral and Coll.; Furedi; Fry and Delong; Grether; Harris and Hagaman; Kernan; Phemister and Grimson; Perint; Ringertz; Schlumberger; Sonesson; Takahashi; Scalori; Scholtz; McKibben and Casey; Wild and Heimendinger; Woodruff; Dintenfass and Coll.; Balzer; Arons, Brunner; Beck; Krogius; Moser; Fetissof; Dijkstra). The ossifying fibroma is a benign tumour with slow development; according to its histological characteristics it has been sometimes referred to as "psammo-osteoid-fibroma" (Goegl), "tumeur fibro-ostéoïde à calcification atypique" (Benjamins), "osteoidoma" (Beck), "fibrous osteoma" (Phemister and Grimson), "psammoma" (Fry and Delong), "osteoid fibroma" (Smelt), "osteofibroma" (Agazzi and Belloni). Phemister and Grimson call "fibrous osteomas" in the cases where mature bone tissue with extensive ossification can be observed, and "osteofibromas or ossifying fibromas" in the cases where the fibrous tissue with immature bone predominate.

The ossifying fibroma has intimate relationship with another type of tumour to be observed at the level of the maxillary bones: the cementoma. The ossifying fibroma and the cementoma may be considered as a similar type of tumour: in cases of ossifying fibroma the bone-forming process gives rise to a bone or osteoid tissue, in cases of the cementoma it gives rise to the cement (Agazzi e Belloni).

The relationship between ossifying fibroma and monostotic fibrous dysplasia is very significant (Skolnik and Fornatto). Monostotic fibrous dysplasia is to be found in the femur, tibia, maxilla and mandible of older children and young adults. Sometimes we observe also an abnormal pigmentation of the skin, a premature sexual development and signs of hyperthyroidism. Many authors (Lichtenstein; Mallory; Schlumberger; Finzi; Agazzi and Belloni; Szanto) state that the ossifying fibroma is a particular kind of monostotic fibrous

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dysplasia. Smith and Zavaleta consider ossifying fibroma as synonymous with monostotic fibrous dysplasia of the cranial or facial bones.

Geschickter and Copeland, Smith and Zavaleta think that ossifying fibroma can evolve into osteoma. Smith and Zavaleta distinguish three types of ossifying fibroma: young, intermediate and mature form: the ossifying fibroma progresses from the young form to the intermediate and the mature ones and there is a parallel between the age of the patient and the maturity of the tumour. These authors observed also an evolution of the mature form of ossifying fibroma to a transitory osteoma and then to the mature form of the osteoma.

The cases of ossifying tumour of the ethmoid are observed very seldom. A thorough study of the literature allowed us to examine the cases described by Scalori; McKibben and Casey; Scholtz; Wild and Heimendinger; Secretan; Benjamins; v. Eicken and Schürmann; Woodruff; Dintenfass and Coll.; Balzer; Brunner.

The purpose of this paper is to report a case of ethmoidal ossifying fibroma we observed in a child aged seven years.

Report of a Case

C. F.—A boy aged 7 years, born in Vittoria (Ragusa). The patient is admitted to the E.N.T. Department of the Turin University on *April 18th, 1959*. Since about two years the child's parents noticed a progressive displacement of the left eyeball to an external position. Since about one year the patient suffered from epistaxis with left nasal stenosis. On admission the nasal septum was deviated to the right; the left middle meatus was found to be occupied by a firm granular red mass; the left eye-ball was displaced to an inferior, lateral and anterior position. There was a slight exophthalmos. The left nasal bone was enlarged, causing the inner canthus of the left eye to be displaced laterally from a symmetrical position. Movements of the eye were normal, so was the fundus oculi too. Blood chemistry and urinalysis were normal.

The X-ray examinations showed a homogenous rounding mass set into the superior half of the nasal cavity and occupying also the ethmoidal labyrinth and the internal portion of the orbit (Fig. 1). The mass was enveloped by a more dense zone (Fig. 2).

The patient was operated on *May 12th, 1959* (Prof. F. Brunetti). The operation was performed under general anæsthesia. A para-latero-nasal cutaneous cut, in the left side, encircles the vestibulum nasi. We demolish the pyriform margin and the ascending process of the superior maxilla as to encircle a big mass with osteo-fibrous capsule, occupying the ethmoid, the nasal cavity, the orbit and the sphenoid sinus. We can remove the mass as a whole, since it is not adherent to the nasal septum, to the nasal cavity or to the orbit. We found only a pedunculus at the level of the cribriform plate.

The removed mass has the size of a small egg, and is enveloped with an osteo-fibrous capsule, as thick as an egg shell.

The microscopic examination showed dense fibrous stroma composed of interlacing bonds of fusiform cells, with acidophilic cytoplasm, showing a tendency toward whorl formations. The nuclei were fairly uniform in size

FIG. 1.

FIG. 2.

and shape and in staining qualities. There were sharply circumscribed, concentrically laminated basophilic bodies (Fig. 3), and numerous calcified and non-calcified bony trabeculae (Fig. 4) containing relatively few osteocytes and osteoid trabeculae (Fig. 5). There were also numerous islands of bone surrounded by osteoid tissue with prominent peripheral osteoblast layers. The bony trabeculae compose a discontinuous envelopment covering the tumour (Fig. 6).

Histologic diagnosis: ossifying fibroma (Prof. G. Mottura).

On *May 27th, 1959*, the patient left the clinic. No recurrences were present a year after the surgical removal.

Conclusions and Summary

We described a case of ethmoidal ossifying fibroma observed in a child seven years old. We wish, first of all, to indicate the seat of development of the neoplasia in the case we observed. Almost all the cases of ossifying fibroma to be found in the literature had developed at the level of the superior maxillary bone, of the inferior maxillary bone or of the frontal bone. The cases with ethmoidal first rising are, on the contrary, very scarce. Really we found in the literature only eleven cases of neoplasia of this type developed at the level of the ethmoidal labyrinth. For this reason we thought useful the publication of this case.

For the most part, the cases of ossifying fibroma reported in the literature were observed in patients aged less than 20 years. Seldom it can be found in

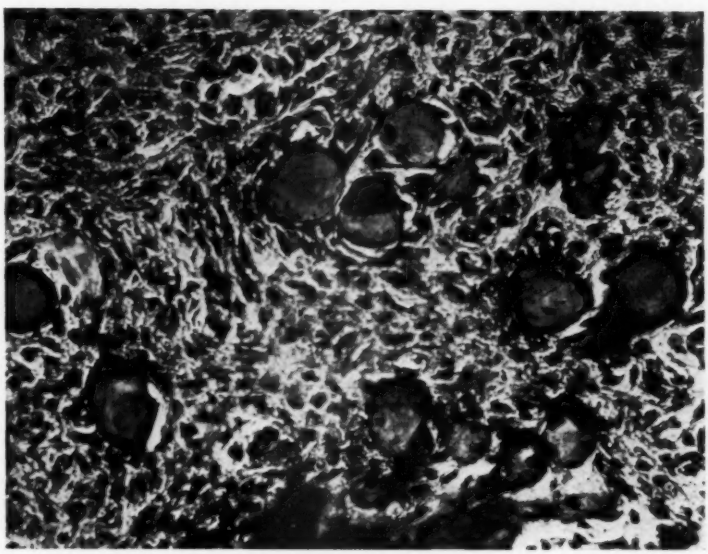

FIG. 3.

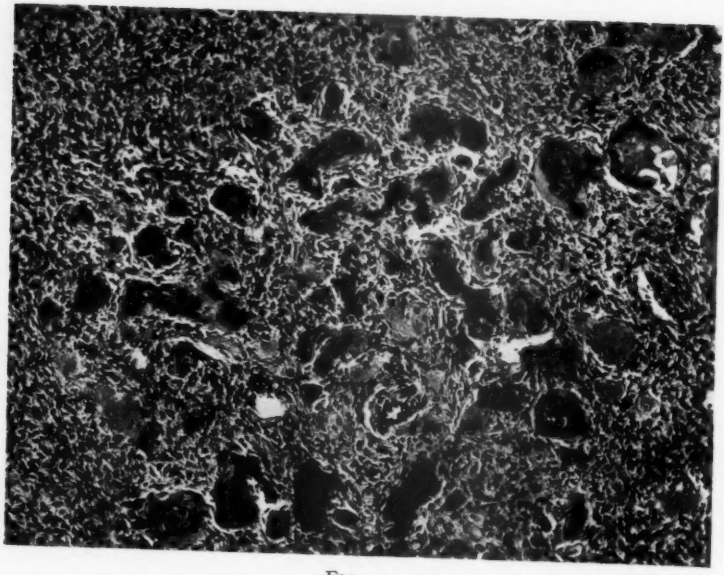

FIG. 4.

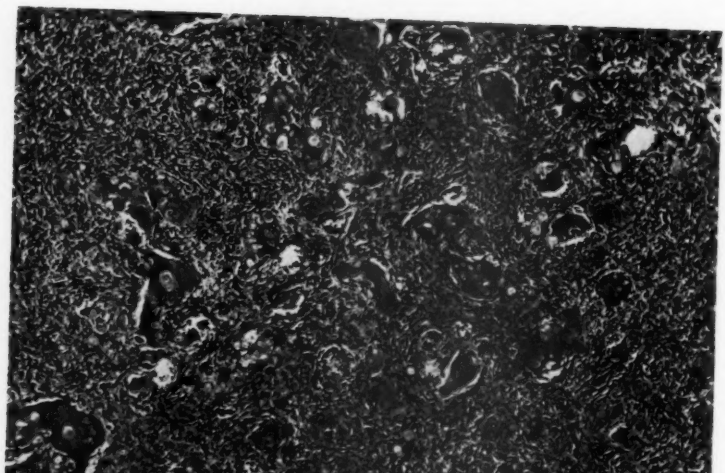

FIG. 5.

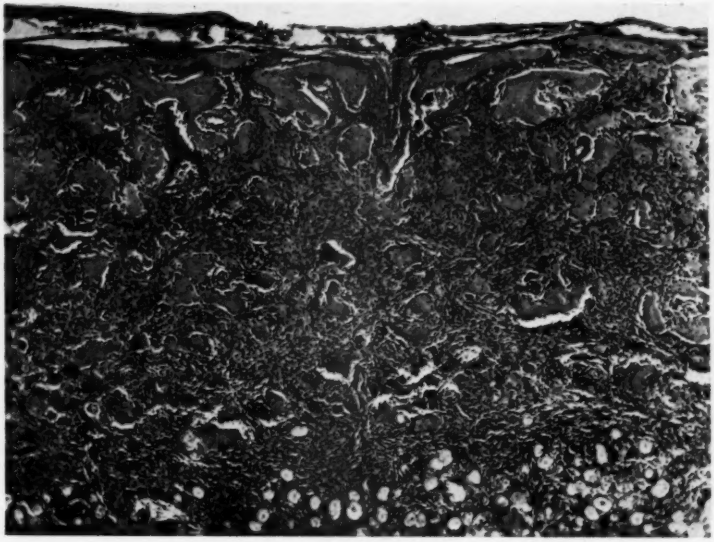

FIG. 6.

patients of a more advanced age. The age of our patient is then in conformity with the data of literature.

Histologically, we wish to underline the presence of a capsule composed of lamellae of mature bone tissue, enveloping the tumour like a shell. Inside we observed on the contrary, an abundant connective stroma where trabaculae of osteoid tissue and sharply circumscribed, concentrically laminated basophilic bodies were immersed. The osteoid tissue was much more abundant than the mature bone tissue; and this fact allows us to consider the tumour as belonging to the intermediate form, according to the classification of Smith and Zavaleta. Besides, its extensive and not piercing growth, the uniformity of the nuclei and lack of mitosis account for the benign nature. The different histologic aspects we can observe in the different parts of the tumour, the presence of osteoid tissue and of bone tissue with prominent peripheral osteoblast layers are expressions of the continuous transformations this tumor undergoes during its growth.

Clinically and symptomatologically our case does not present elements of particular interest.

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CYLINDROMA OF THE HARD PALATE PRESENTING AS A NASAL POLYP

By A. E. GREEN and E. H. RAINER (Orpington, Kent)

BILLROTH in 1859 first used the term cylindroma to describe a slow growing weakly invasive carcinoma of salivary gland tissue having a histological pattern suggestive of cylinders of cells. Metastases to lung have been described. Local spread, though slow, may be extensive before a diagnosis is made and the tumour characteristically extends along lines of greater resistance.

Harrison (1956) in a study of 82 ectopic salivary adenomata, found that 49 were cylindromatous. In this series cylindromata formed 66 per cent of neoplasms of ectopic salivary tissue, whereas only 8 per cent of parotid neoplasms were of this type. He also noted that the sex incidence of mixed adenomata was equal whereas females outnumbered males in the proportion of 2 to 1 in the case of cylindroma (mixed adenomata, 15 female, 14 male; cylindroma, 30 female, 16 male).

The treatment recommended by him was radical diathermy excision with a wide margin of normal tissue if the neoplasm were surgically accessible. If not, irradiation was advised.

Koltai (1959) considered that cylindromata could "arise at any site where mucinous glands are present; in the upper or lower air passages, alimentary canal, etc. It can also start from a sebaceous gland, and it is in this way that cylindromas occur in the auditory meatus or, as a Spiegler's tumour, on the scalp (Lezler)". He suggested that all polyps in the nose or other air passages be histologically examined.

The present case closely resembles Koltai's.

Case History

Mrs. E., aged 42, was seen in the Out-Patient Department for the first time on *September 24th, 1959*, complaining of blocking of the left nostril for 6-7 months. Occasionally on blowing her nose she had noticed slight bleeding.

On examination there was a fleshy polyp in the middle part of the floor of the left nostril. This was removed and sent for microscopy. X-ray of the sinuses on that day showed only slight haziness in the floor of the antrum, and no bone erosion.

The Pathologist's report was that the polyp was a neoplasm belonging to the pleomorphic salivary gland tumour group and having a cylindromatous appearance (Fig. 1).

The patient's admission to hospital was arranged. It was then found that

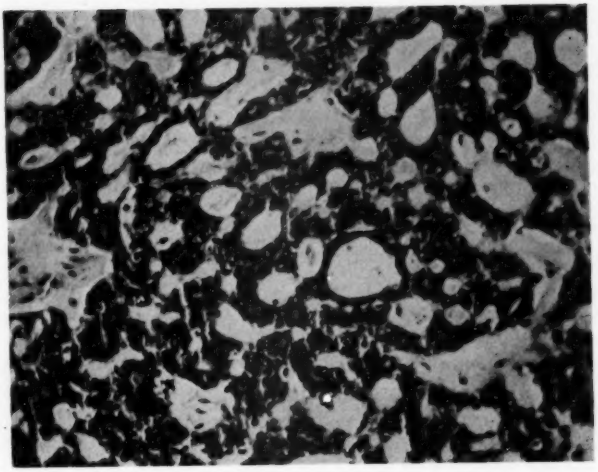

FIG. 1(*a*).

Polyp removed in September 1959, showing cylindromatous nature (× 30). Note marked cellularity compared to original biopsy in January 1957 (Fig. 2a and 2b).

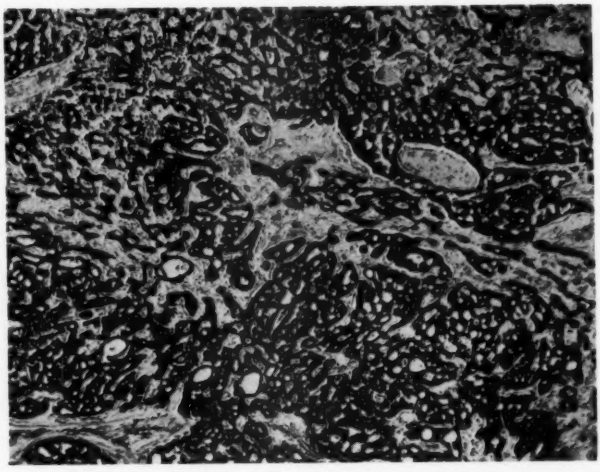

FIG. 1*b*.

Typical field of tumour removed in September 1959 (× 140).

she was already on the waiting list for a bed in the Dental Unit. She had attended the Dental Clinic for pain in the region of the socket of the left upper first molar, extracted some months previously. This region had been found to be slightly swollen and tender and dental X-ray showed an area of translucency. She had been advised curettage of the area.

On questioning her in hospital about past illnesses, she said that she had had a lump removed from the roof of her mouth at another hospital in *January, 1957*. On pursuing this it was learnt that this lesion had been an "adenocystic carcinoma". A section of this lesion was obtained and was found to be similar to, but less cellular, than the nasal polyp (Fig. 2). This excision in 1957 had been followed by irradiation with a Radium applicator (dosage 4,000r). She had been followed up by the Radiotherapy Department concerned and when last seen in *July, 1959*, was asymptomatic and there was said to be no abnormality on examination.

On reviewing the previous history and histological findings, it was decided to irradiate the involved area and to follow this by radical diathermy excision.

She received a tumour dose of 6,039r from a 2 million volt Van de Graaff generator over a period of seven weeks starting on *November 3rd, 1959* (Dr. K. A. Newton).

Operation (E.H.R.) was performed as follows: Diathermy incision through mucosa, across the midline to include the right central incisor and extending laterally to include the second left molar tooth and maxillary tuberosity. The floor of the nose, inferior half inch of the nasal septum and anterior inch of

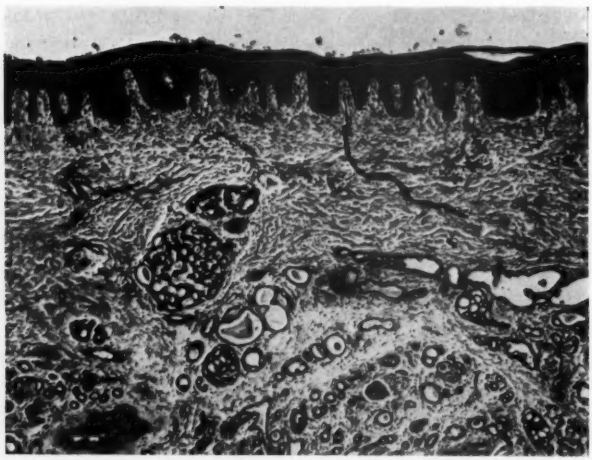

FIG. 2(*a*).

Cylindroma removed in January 1957 showing mucosa of hard palate (× 30). Beneath intact mucosa mucus containing spaces lined by small epithelial cells, characteristic of this tumour.

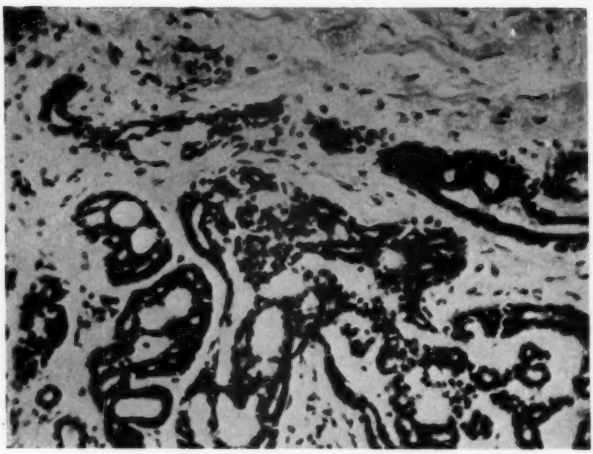

FIG. 2(*b*).
Typical field of cylindroma removed in January 1957 (× 140).

the left inferior turbinate were removed. The cavity was packed with B.I.P.P. gauze and an acrylic dental prosthesis fitted, built up with dental composition.

The Pathologists' report on the excised tissue was as follows:

Sections examined from both the anterior nasal floor and from the nasal mucosa show no evidence of tumour infiltration. Also blocks taken from the medial side of the specimen show no tumour. However, beneath the epithelium, which exhibits necrosis, and overlying the hard palate, can be seen the characteristic pleomorphic salivary tumour, the clumps of polyhedral cells surrounded by leucocytic infiltration and showing in some places radiation necrosis.

She made an uninterrupted recovery from the operation and admitted to little discomfort until mid-April when she said the prosthesis hurt at one point. A few small bone sequestra were removed.

Fig. 3 shows final appearance of fenestrated palate.

Repeated chest X-rays have been normal. She had been fitted with a dental prosthesis (Figs. 4 and 5).

Fig. 6 shows patient inserting obturator, Fig. 7 with obturator in situ.

Summary

This is a report of a case of cylindroma of the hard palate occurring in a woman of 42 years of age. She presented herself with a nasal polyp 2 years after a palatal lesion had been treated elsewhere by local excision and irradiation. The polyp was removed in the Out-Patient Department and proved histologically to be a cylindroma. Subsequent treatment was by en bloc excision of the maxilla after high voltage irradiation.

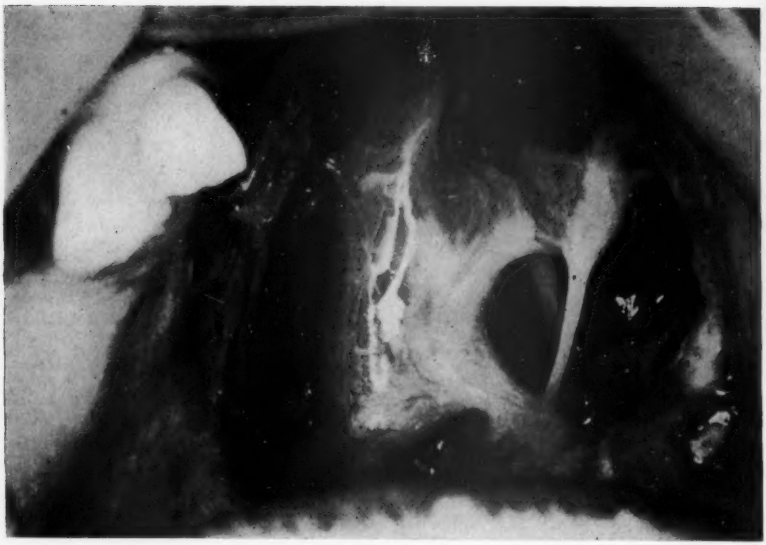

FIG. 3.

Fenestrated palate. Very wide excision well across midline because of known tendency of these tumours to spread widely beyond their visible extent. This tumour, moreover, had recurred 2½ years after irradiation.

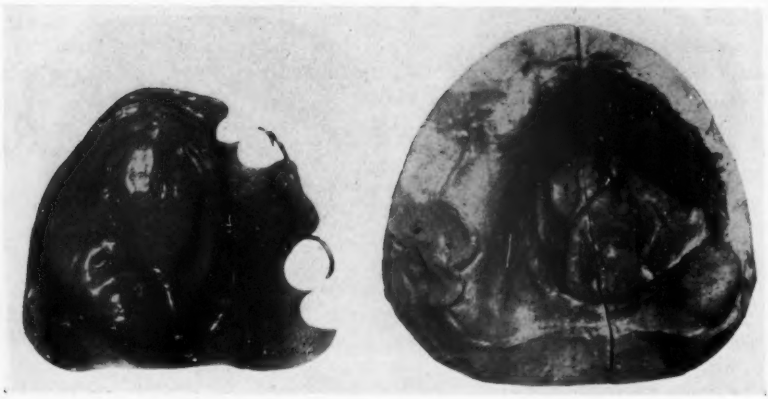

FIG. 4.

Obturator and Cast.

FIG. 5.
Obturator.

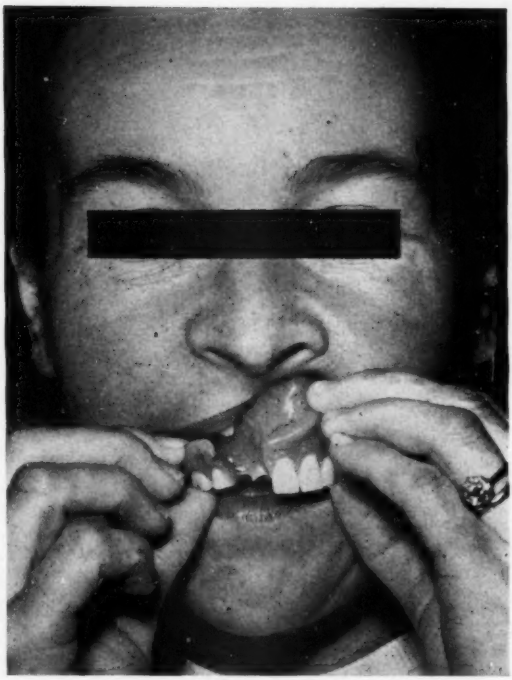

FIG. 6.
Fitting Obturator.

FIG. 7.
Patient with obturator in position.

Acknowledgements

We wish to express our thanks to Dr. K. A. Newton, Radiotherapist, Westminster Hospital, Dr. Keith J. Randall, Pathologist, Orpington Hospital, the Dental Prosthetics and Photographic Departments, Guy's Hospital, and Photographic Department, Southern Group Laboratories, Hither Green.

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SUBMUCOSAL INJECTIONS OF HYDROCORTISONE FOR ALLERGIC RHINITIS AND RHINITIS MEDICAMENTOSA

By G. GORDON MOWAT (Bolton)

THE following is a summary of the literature on this subject.

Wall and Shure (Los Angeles) 1952, treated five cases of polypi by submucous injection of the turbinates. The turbinates shrank up and made removal of the polypi easier.

Sidi and Tardiff in Paris, 1955, injected the anterior third of the inferior turbinates and also the septum.

Walter Owen, 1956, injected Hydrocortisone into the substances of polyps. The injections were made on three occasions at weekly intervals. There was marked reduction in the size of the polyps.

E. Clerici, L. Teseo, G. Massara, report in the Archives of Italian Otology 1955, the local use of cortisone and hydrocortisone by endonasal submucous injections in various clinical forms of vasomotor rhinopathies. Eighty-three patients have been treated, twenty of them suffering from hay fever and sixty-three from vaso-rhinitis. Only slight improvements have been obtained in cases of hay fever. In vasomotor rhinitis 60 per cent. of favourable results have been observed with Cortisone and 80 per cent. with hydrocortisone.

The following is a report on sixty-two cases treated at the Bolton Royal Infirmary since 1958:

Technique. The solution used is a 2·5 per cent. sterile aqueous solution of Prednisolone (Roussell) made up in 5 ml. vials containing 125 mg. of Prednisolone and used usually for intra or peri-articular injection. A 25 gauge 3½ in. needle is inserted into the anterior end of the inferior turbinate and slid along submucosally for about half its length. Extreme care is required not to perforate the mucosa as this results in loss of some of the solution. The injection is made slowly and the turbinate will be seen to swell and turn pale in colour. The needle is slowly withdrawn injecting at the same time. It is advisable to wait for a few moments before withdrawing the needle completely in order to avoid loss of solution. The usual dose has been 2 cc. into each inferior turbinate.

The injection can also be made into the middle turbinate and the septum.

Results

Fifty-nine cases of allergic rhinitis and three cases of rhinitis medicamentosa have been treated by this method. The results are tabled below.

Although twenty-two of these cases have had other operative treatment at the same time (sub-mucous resection or polypectomy), fifty-five (88 per cent.) show definite improvement. This improvement usually takes place on the third day and symptoms are relieved within a week. The three main symptoms—

Case No.	Age	Sex	Disease	Injection of Prednisolone Date	Other Treatment	Results			Comments
						Sneezing	Nasal Obstruction	Discharge	
1	33	M	Allergic Rhinitis	3 Oct. '58		Less	Less	Less	For last two weeks further obstruction. For repeat.
2	49	F	Ditto	18 Nov. '58	S.M.R. 12.2.59	Less	Less	Less	13 Oct. '59 Some obstruction. Result of S.M.R. Not very satisfactory
3	31	F	Ditto	7 Oct. '58		Less	Imp.	Less	Some recurrence when hay fever season started.
4	31	F	Ditto	3 Oct. '58	Tab. Prednisone 5 mg. b.d.	ISQ	ISQ	ISQ	Appearance improved. Airway Adequate.
5	55	F	Ditto	28 Oct. '58	Ditto	ISQ	ISQ	ISQ	O.E. airway seems adequate.
6	29	F	Ditto	25 Nov. '58		Less	Less	Less	Marked improvement.
7	20	M	Ditto			Same	Less	Less	Questionnaire only.
8	28	M	Ditto Bencard Neg.	17 Oct. '58	Cautery 5.11.56	Less	Less	Less	Questionnaire.
9	28	M	Allergic Rhinitis	11 Nov. '58		Less	Less	Less	Questionnaire.
10	26	F	Allergic Rhinitis	30 Sept. '59		ISQ	ISQ	ISQ	Appearance of turbinates less swollen.
11	22	M	Ditto and Polypi L.	21 Dec. '59	Polypectomy	ISQ	ISQ	ISQ	Congestion may have been less. Colds less numerous.
12	13	M	Allergic Rhinitis	17 Dec. '59	Tonsillectomy	Less	Less	Less	No trouble since.
13	13	M	Allergic Rhinitis Bencard Neg.	24 Sept. '59		ISQ	ISQ	More	Chest trouble.
14	17	F	Allergic Rhinitis	10 Dec. '59	Tonsillectomy	Less	Less	Less	
15	57	M	Ditto and Asthma	10 Sept. '59		ISQ	Less	ISQ	
16	54	F	Allergic Rhinitis. Polypus D.N.S.	24 July '59		More	Less	More	No sneezing for first few weeks.
17	13	F	Allergic Rhinitis and Asthma	27 Nov. '58	S.M.R.	More	Less	More	
18	37		Allergic Rhinitis		S.M.R.	Less	Less	Less	Marked improvement.
19	13	F	Ditto	28 May '59	25 Aug. 1958 S.M.R. and Cautery	More	More	More	No improvement.
20	53	M	Ditto	31 Dec. '59	S.M.R. and Polypectomy.	Less	Less	Less	No symptoms now.
21	56	F	Ditto	28 Sept. '59		Less	Less	ISQ	c/o post nasal drip.
22	62	M	Ditto and Polypi	28 Dec. '59	Polypectomy	Less	Less	Less	No trouble since.
23	37	F	Allergic Rhinitis and Polyp L.	31 Dec. '59	Polypectomy	Less	Less	Less	Some loss of taste and smell.

24	30	F	Allergic Rhinitis and Polypi.	21 Sept. '59	Ditto	Less	Less	ISQ	Worse in smoky room.
25	49	F	Allergic Rhinitis	12 Feb. '59 29 May '59	S.M.R.	Less	Less	Less	Much improved after second injection.
26	44	F	Ditto and Polypi.	26 Feb. '59	Polypectomy	Less	Less	Less	Long history of polypi. Improvement greater this time.
27	40	M	Allergic Rhinitis.	28 Feb. '59		ISQ	ISQ	ISQ	Improved on tablets from own Doctor.
28	7	F	Ditto	26 Oct. '59	June 1955 Cautery.	ISQ	ISQ	ISQ	
29	47	F	Ditto	23 Feb. '59	S.M.R.	Less	Less	Less	
30	18	F	Ditto	8 Apr. '60		Less	Less	Less	Appearance of turbinates now normal.
31	59	F	Ditto	4 Jan. '60		None	Less	Less	Appearance normal.
32	15	F	Ditto	10 Dec. '59	Tonsillectomy	None	None	Less	Slight D.N.S. not now affecting her.
33	13	F	Ditto	20 Mar. '60		Less	Slight	None	
34	11	M	Allergic Rhinitis.	24 Nov. '59 24 May '60		Less	ISQ	ISQ	Very little improvement.
35	50	F	Ditto	?		None	Less	Less	
36	50	F	Rhinitis Medicamentosa.	?		None	None	None	Can now do without Fenox.
37	15	M	Allergic Rhinitis.	24 Dec. '59		Less	Less	Less	Nasal injury since. Requires S.M.R. now.
38	23	F	Ditto	9 May '60	S.M.R.	None	None	None	Recovery of taste and smell
39	39		Ditto	21 June '60		Less	Less	Less	R.M.O. Hulton Lane.
40	16	M	Ditto	21 Jan. '60	S.M.R.	Less	None	None	
41	55	M	Ditto and Polypi.	31 Dec. '59	S.M.R.	None	None	None	
42	13	M	Allergic Rhinitis.	17 Dec. '59		None	ISQ	ISQ	Needs S.M.R.
43	31	F	Ditto	14 Oct. '58 11 Nov. '60	S.M.R.	Less	None	Less	
44	18	M	Ditto and Polypi.	25 Apr. '60	S.M.R.	None	Less	Less	
45	11	F	Allergic Rhinitis.	5 May '60		Less	Less	Less	O.E. Turbinates still swollen.
46	16	F	Allergic Rhinitis.	27 Nov. '58 11 Jan. '60	S.M.R. 1958	Less	ISQ	None	
47	38	M	Allergic Rhinitis and Polypi.	18 Aug. '60	S.M.R.	Less	None	None	
48	13	F	Allergic Rhinitis.	11 Aug. '60		Less	Less	Less	
49	11	M	Ditto	11 Dec. '58 26 Feb. '60		Less	None	Less	Previously could not breathe through nose at all.
50	50	F	Ditto	12 Nov. '59 29 May '59	S.M.R.	Less	Less	Less	c/o post nasal drip.
51	37	M	Ditto	4 May '59	S.M.R.	Less	Less	Less	Nose aches in cold weather.
52	35	F	Ditto	18 July '60	Zinc Ionisation 1957. Cautery 1958.	Less	None	None	

Case No.	Age	Sex	Disease	Injection of Prednisolone Date	Other Treatment	Results			Comments
						Sneezing	Nasal Obstruction	Discharge	
53	7	M	Ditto	8 June '59	Benadryl 25 mg. b.d.	Less	Less	Less	
54	62	F	Ditto	19 Dec. '58 9 Jan. '59	Benadryl	Less	None	Less	
55	58	F	Ditto	24 May '60	A.P.—clear	None	None	None	Feel very well.
56	54	F	Ditto	29 Mar. '60	A.P.	Less	Less	Less	Much improved
57	32	M	Ditto and D.N.S.	19 July '60	S.M.R.	None	Less	None	Very satisfactory.
58	28	F	Rhinitis Medicamentosa.	2 Oct. '59		Less	Less	Less	Much improved.
59	73	F	Allergic Rhinitis.	20 May '60	Polypectomy.	Less	Less	Less	
60	40	M	Allergic Rhinitis and Polypi.	3 June '60	Previous Polypectomies	Less	Less	Less	
61	21	M	Hay Fever	17 Nov. '59	S.M.R.	None	Less	Less	
62	19	F	Rhinitis Medicamentosa.	13 June '60		None	None	Less	Has discontinued Drops.

CASES IMPROVED

	Without other operative treatment at same time (35)	*With* other operative treatment at same time (27)
Sneezing	23 (65%)	48 (77%)
Nasal Obstruction	24 (68%)	48 (77%)
Discharge	22 (62%)	46 (74%)

sneezing, nasal obstruction and a clear nasal discharge—are all usually relieved to some extent.

The most dramatic results are obtained in cases of rhinitis medicamentosa. The appearance of the mucosa is red and congested and not like the pale, purplish mucosa of allergic rhinitis. The swelling is usually confined to the anterior half of the turbinate, i.e. the area which receives the full strength of the decongestive nasal drops which the patient has been using. Submucosal injection of hydrocortisone causes shrinkage in three days and the patient can easily give up using nasal drops.

Conclusion

This is a form of treatment which relieves the patient from continued use of nasal drops and antihistamines by mouth. The injections are painless and easy to do and may be repeated. Failure the first time indicates that further injections may also fail. The results are quicker and not so disturbing as either linear cautery or zinc ionization.

Many cases have had other operative procedures either at the same time or subsequently, particularly submucous resection of the septum. A submucous resection of the septum seems to produce excellent results in combination with submucosal injection of hydrocortisone to the turbinates. Polypi have nearly always been removed, but the few polypi that I have injected seem to shrink in size. They have mainly been attached to the middle turbinate.

It is important to make sure that there is no infection present by X-ray of sinuses and antral-puncture in cases of doubt.

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ENCYSTED CHOLESTEATOMA FOLLOWING MASTOIDECTOMY

By JEFFERY POTTER (Liverpool)

THE development of encysted cholesteatoma following mastoidectomy has been described on a number of occasions. Begley and Williams (1951) described two cases occurring after radical mastoidectomy for the removal of aural cholesteatoma. One, six years after operation, developed a cyst beneath the mastoid scar which was found at operation to contain cholesteatoma and to extend from the mastoid into the neck. The other, a post-auricular swelling developing four years after radical mastoidectomy, was found to be a subcutaneous cyst filled with cholesteatoma connected with the mastoid cavity. They postulated that these lesions developed from recurring cholesteatomatous matrices and like Ruedi (1957) they stressed the importance of complete removal of the cholesteatomatous matrix. Turnheim (1955) described a cholesteatomatous cyst deep to the sternomastoid occurring four years after radical mastoidectomy. It was found to be connected to a large mastoid tip cell which was filled with cholesteatoma. Bauer (1952) described two cases of subcutaneous cyst containing cholesteatoma occurring beneath a post-auricular scar following radical mastoidectomy and having no connection with the cavity, and considered that they were due to implantation of cholesteatomatous debris at the original operation. Lurie (1955) described a cholesteatoma occurring above a radical mastoid cavity which eroded the squamous temporal and extended into the middle cranial fossa, pushing the dura medially. Anderson (1956) described cholesteatoma of the tympanum following mastoidectomy in cases where the mastoid cavity had become shut off from the tympanum by false membrane and demonstrated continuity of the cholesteatoma with the skin of the external auditory meatus. Reading (1958) described two cases of cholesteatomatous cysts of the neck following radical mastoidectomies. In each case he was able to demonstrate a definite track from the mastoid cavity to the cyst.

Case Report

A man of 34 years was seen in the clinic on *27.6.1960*. He had had a left radical mastoidectomy 25 years previously. His ear had always discharged a little since the operation, but during the previous week the discharge had become more profuse and he had developed a painful swelling behind the ear. He was found to have a dirty neglected mastoid cavity with red granular walls and a tender doughy swelling was found deep to the post-auricular scar. A mastoid X-ray (Fig. 1) showed a large circular cavity posterior to the mastoid cavity on the left side and apparently separated from it by bone.

He was advised to have an operation but, for domestic reasons, his admission was delayed and he was given daily Penicillin injections in the meantime. On

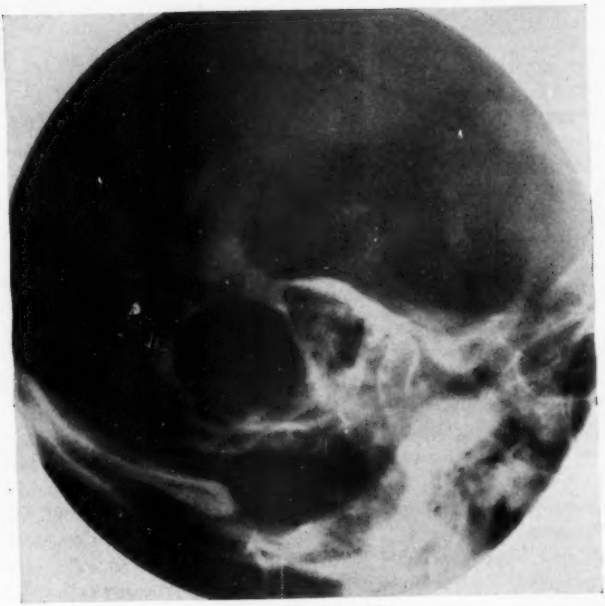

FIG. 1. L. Mastoid.

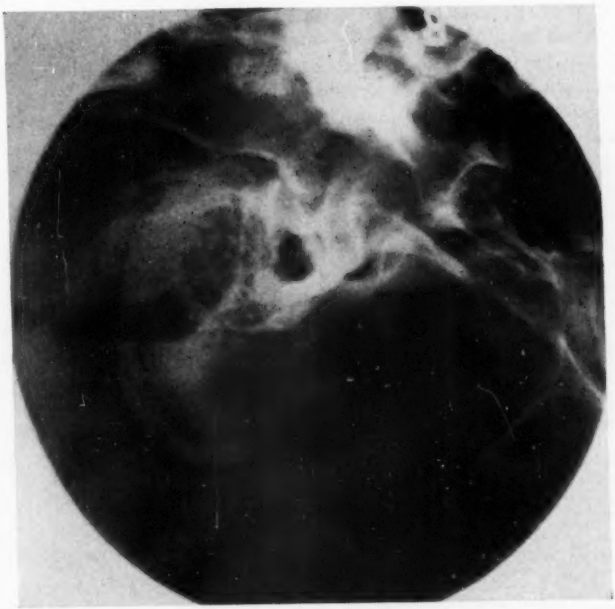

FIG. 2. R. Mastoid.

6.7.1960 an exploratory operation under local anæsthesia was carried out. Incision over the anterior part of the swelling revealed a large cholesteatoma with some purulent exudate. On removing the cholesteatoma, it was found to have created a large cavity, separate from the old mastoid cavity and exposing the sigmoid sinus almost to the jugular foramen. Behind, the cerebellar dura in the posterior fossa was exposed. A conchoplasty was performed to open into this cavity and the fibrous-osseous wall between it and the old mastoid cavity was removed. Some pus was found exuding from the lower angle of the cavity and a sinus was found in that angle extending into the digastric fossa. A swab produced a growth of *Staph. pyogenes*. The post-operative course was uneventful.

Discussion

The diagnosis in this case was obvious. The previous mastoidectomy and the striking X-ray appearance pointed unequivocally to a post-operative enclosed epidermosis. The operation was quite simple and in the absence of severe infection and under local anæsthesia there was minimal bleeding and all vital structures were easily identified. Even so, some difficulty was found in ablating the fibro-osseous bridge between the mastoid cavity and the cyst. The picture would have been different if more severe infection had supervened and the case might well have presented with sinus thrombosis or cerebellar abscess and an emergency operation undertaken without recourse to radiography. The surgeon entering such a large cavity might easily think he was in the mastoid cavity itself and proceed to search for the lateral sinus in its posterior wall instead of the antero-medial surface.

Had it not been for the onset of infection, the extension through the lower angle of the cavity in time might have produced a cholesteatomatous cyst of the neck similar to those described by other authors (supra).

The possibility that this might be a congenital epidermoid cyst need not be seriously entertained in view of the far bore plausible diagnosis of post-operative implantation epidermosis. Not infrequently however, similar large intra-temporal cysts have been described in the absence of previous operation. These cases have been regarded as epidermoid cysts of congenital origin (Jefferson and Smalley 1938). Pennybacker (1944) and Lundgren (1948) describing such cases, attributed their presence to infection in an outlying mastoid air cell and Simpson (1957) describing a smilar case points to the evidence of previous infection, and it is not difficult to envisage a spontaneous encystment of epidermosis during the course of such a chronic inflammation.

Acknowledgements

I wish to thank Mr. A. Tumarkin for his permission to publish this case and for his advice in the preparation of this paper. My thanks are also due to Dr. P. Whitaker for the skiagram.

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ANTROLITH

By H. WICKHAM (Sunderland)

THE recent interesting paper on Antral Rhinolithiasis by D. J. Brain brought to light two rather surprising facts. These are (1) the small number of such cases which have been reported and (2) the infrequency of finding a tooth, or part of a tooth, forming the central nucleus of the stone. Of the fourteen cases recorded, in only one was a tooth root the nucleus of the stone.

I submit that antrolith is the correct term for this condition. The word rhinolith means "nasal calculus" or "concretion in the nose". "Antral rhinolith" would suggest that a rhinolith has eroded the naso-antral wall and is now present wholly or partly in the antrum.

A further case history is considered worth recording, in view of the facts already mentioned:

T.B., a man of 50 years, was first seen on *13.11.56* having been referred from the Eye Infirmary, Sunderland. He was suffering from acute iritis of the right eye and his sinuses had been X-rayed in a search for a focus of infection. The X-rays revealed a generalized and marked opacity of the right antrum consistent with maxillary sinusitis.

Antral lavage produced a large amount of offensive pus. The patient was too ill to attend the following week but reported again seventeen days after his original attendance (*30.11.56*) when antral lavage again produced offensive pus + +. Three further washouts were carried out at weekly intervals without any amelioration in the infection. He was therefore admitted to hospital and a right Caldwell-Luc operation was performed on *7.1.57*. The findings at operation were:

(1) empyema of antrum, the sinus being full of thick offensive pus;

(2) a staghorn antrolith.

His convalescence was uneventful and his condition remained satisfactory thereafter.

The stone was sent for examination in the Laboratory and the following report was received:

"The dried stone was greyish coloured and of irregular shape; length 20 mm. and thickness varying from 5 mm. to 10 mm. Weight 1·6 gm. On powdering a tooth root was found in the centre of the stone. Chemical composition = calcium phosphate with some magnesium."

I wish to record my thanks to Mr. R. E. Jowett for permission to publish this case history and to Dr. J. F. Wilson and Dr. P. Trinder for the analysis of the stone.

REFERENCE

BRAIN, D. J. (1960) *J. Laryng.*, **74**, 42.

Royal Infirmary,
Sunderland

GENERAL NOTES

VIIème CONGRÈS INTERNATIONAL O.R.L.

Le VIIème Congrès International O.R.L. se tiendra du 23 au 29 juillet 1961 à Paris, à la Nouvelle Faculté de Médecine, Rue des Saints-Pères, sous la présidence de M. le Professeur Aubry.

Trois très importants rapports seront discutés:

1°) Les acquisitions récentes en pathologie et en thérapeutique de l'otosclérose.
Rapporteurs: MM. les Professeurs Sourdille, Sercer and Krmpotic, Weber, Ardouin, Larroude, Ferreri and Schambaugh.

2°) Indications et résultats après 5 ans, de la chirurgie et des associations radio-chirurgicales dans le traitement des cancers du larynx et de l'hypopharynx.
Rapporteurs: MM. les Professeurs Pietrantoni and Agazzi, Alonso, Casadesus, Chevalier-Jackson, Leicher, Leroux-Robert, Ormerod.

3°) Rapports entre l'allergie et les infections du nez et des bronches.
Rapporteurs: MM. les Professeurs Van Dishoeck, Clerici, Hlavacek, Voohorst, Mayer, Laskiewicz, Teracol.

De nombreuses réunions et festivités sont envisagées pour les Congressistes et leurs épouses. A la suite du Congrès, des excursions auront lieu; elles seront proposées dans un avant-programme et réalisées par les soins des Wagon Lits Cook, 22 rue de l'Arcade, Paris, qui sont notre agent officiel habilité pour les transports et réservations d' hôtels.

Pour tous renseignements, écrire au Dr. Henry Guillon, Secrétaire Général, 6 avenue Mac-Mahon, Paris.

THE INSTITUTE OF LARYNGOLOGY AND OTOLOGY

330-332, Gray's Inn Road, London, W.C.1.

SHORT COURSES

for

CONSULTANTS AND SENIOR REGISTRARS

28th and 29th April, 1961.—Practical Aural Surgery Class.

NON-MEDICAL COURSES

31st May, 1st and 2nd June, 1961—Hearing and mental assessment of the deaf child—for psychologists.

The number of entries is limited in each course. A detailed syllabus of the above can be obtained on application from the Secretary-Administrator.

General Notes

SPECIAL LECTURES

Saturday, 6th May, 1961. Symposium beginning at 10 a.m.

Professor Otto Löwenstein, Birmingham. "The evolution of static and acoustic sense organs."

Dr. Hallowell Davis, St. Louis. "The relation of presbyacusis to noise-induced hearing loss."

Dr. Juergen Tonndorf, Iowa City. "Cochlear hydrodynamics."

UNIVERSITÀ DEGLI STUDI DI BOLOGNA
PREMIO INTERNAZIONALE "PIETRO CALICETI"

Announcement of the conditions for the International Prize Pietro Caliceti

The conditions for the "International Prize Pietro Caliceti" are herewith announced. The prize honours the memory of Prof. Pietro Caliceti, deceased distinguished Professor of Clinical otorinolaringojatrica of the University of Bologna.

The prize will be awarded to an Italian or foreign graduate in Medicine and Surgery, who during the four-year period of time (November 1, 1956 to October 31, 1960) has or will publish a scientific work of unquestionable value and of recognized originality in the field of otorinolaringologia.

The prize consists of: (*a*) a gold medal, minted from the original mould used by Mrs. Inez Misley, the widow Caliceti; (*b*) a cash prize of 1.000.000 Lira; (*c*) Diploma testifying to the receipt of the prize itself.

The Committee of Judges will be composed of: (1) The Dean of the Faculty of Medicine and Surgery of the University of Bologna. (2) The Professor of Clinical Otorinolaringologia of the University of Bologna. (3) The President of the Italian Society of Otorinolaringologia. (4) The Professor of Clinical Surgery of the University of Bologna. (5) The professor of Human Physiology of the University of Bologna.

If in the final judgement of the Committee, none of the works presented by the competitors demonstrates outstanding value and originality, they may decide not to award the prize.

By April 10, 1961 the competitors must send to the "Segreteria dell'Università di Bologna" the following documents: (*a*) an application addressed to the Magnifico Retoret dell' Università degli Studi di Bologna; (*b*) a curriculum vita; (*c*) six copies of each scientific work submitted for the examination for the prize (five of these will go to the members of the Committee of Judges).

In addition, the Committee of judges may give consideration in awarding the prize to informations and data submitted by the above mentioned date by foreign or Italian Universities or by the three societies of Otorinolaringologia: Italian, Latin, International.

General Notes

TEMPLE UNIVERSITY SCHOOL OF MEDICINE

PHILADELPHIA 40. PA.

A "Short course in Audiology" is offered several times each year by the Section of Audiology, Department of Otorhinology, Temple University School of Medicine, Philadelphia 40, Pa.

The course will be one week in length and will encompass theoretical and clinical aspects of audition. Hearing testing and interpretation will be stressed. Office procedures, equipment and Industrial Audiometry will be discussed.

Further information may be obtained by writing to Philip E. Rosenberg, Ph.D., Director, Section of Audiology, Temple University Medical Center, 3401 North Broad St., Philadelphia, Pa.

ROYAL COLLEGE OF SURGEONS
OTOLARYNGOLOGY LECTURES

THE following lecture, arranged jointly by the Royal College of Surgeons of England and the Institute of Laryngology and Otology, will be delivered in the Lecture Hall of the College on Thursday afternoon at 5.30 p.m.

1961

May 4th. DR. R. BODLEY SCOTT. "Blood diseases in relation to Otolaryngology."

UNIVERSITÉ DE BORDEAUX
—FACULTÉ DE MÉDECINE ET DE PHARMACIE
CLINIQUE OTO-RHINO-LARYNGOLOGIQUE

COURS DE PERFECTIONNEMENT

Du Professeur G. Portmann

DU LUNDI 10 AVRIL AU SAMEDI 22 AVRIL 1961

Les inscriptions sont à adresser à: M. le Professeur G. Portmann, 45, cours Maréchal-Foch, Bordeaux

DROIT D'INSCRIPTION: 300 NF.

A verser a la Faculté de Médecine, Au Début des Cours.

THE INTERNATIONAL COURSE IN PAEDO-AUDIOLOGY

JUNE 13TH-16TH, 1961

It is intended to organize at Groningen University, The Netherlands, a second international course in paedo-audiology, in close co-operation with the Royal Institute for the Deaf and the Institute for the Hard of Hearing, Groningen. As was also the case in the first course, which was held in 1953, the

problem of the hearing handicapped child will be the feature of the programme. Special emphasis will be laid on the educational treatment of young children.

The course, which will take place from June 13th to 16th, is subsidized by the World Health Organization and Unesco. The official language is English. The subscription is 60 Dutch guilders. Those who are interested in participating in the course are requested to send their application to the Audiology Department of the University Hospital, Groningen.

Participants are requested to book hotel accommodation at their earliest convenience. The course fee may be sent by bank transfer to "Mesdag en Groeneveld's Bank, 17 Oude Boteringestraat Groningen" in favour of "International Course in Paedo-Audiology".